THE AMERICAN MALACOLOGICAL UNION, INC.

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Pacific Division

ANNUAL REPORTS for 1968

AMU, Thirty-Fourth Annual Meeting
AMU, PD, Twenty-first Annual Meeting

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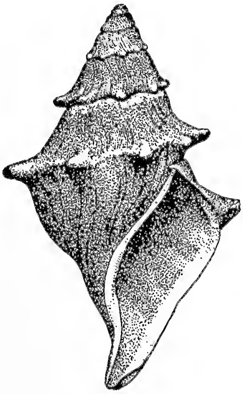

AMU, Thirty-Fourth Annual Meeting

AMU, PD, Twenty-first Annual Meeting

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Mailed, December 27, 1968

THE THIRTY-FOURTH ANNUAL MEETING OF THE AMERICAN MALACOLOGICAL UNION

Corpus Christi, Texas July 15 through 19, 1968

"Y'-all come to Texas in 1968 and we'll take it from there!" They promised and they delivered and it all added up to what was perhaps the finest annual meeting the American Malacological Union has ever enjoyed. Certainly it was the largest, but for Texas that surprised nobody.

Corpus Christi had been chosen by the six shell clubs whose members jointly hosted the meeting as offering most in combination of good hotel facilities and easily reached collecting areas. Located high above Corpus Christi's fabulous harbour, the Robert Driscoll Hotel provided fine lodging, restaurant and meeting facilities—all, of course, completely air conditioned.

On Sunday as always, a goodly percentage of the delegates began to assemble and by evening at least fourscore were on hand to enjoy the first of a series of 'happenings.' Hosted by the Padre Island Shell Club, this was a Plantation Party; in the early dusk in a room off the swimming pool terrace members of the club served punch and other goodies, sparing no effort to make their guests feel welcome and comfortable.

Another team took over on Monday morning, manning the registration desk in the hotel lobby. As each guest registered he was given a bulging bag containing a variety of articles ranging from sun glasses to potato chips, all gifts of local manufacturers or their dealers.

At one-thirty most of the 178 who ultimately were registered had taken seats in the hotel's Flamenco Room. President Arthur H. Clarke introduced the Honorable Jack R. Blackwell, Mayor of Corpus Christi and the 34th Annual Meeting of the AMU was under way.

In readying his brief address of welcome, said Mayor Blackwell, he had learned a new word. He confessed having been driven to the dictionary to learn the meaning of "malacological." Now that he knew, he had been able to add a final line to a couplet familiar to his fellow Texans but perhaps not to their guests. Corpus Christi, said he, is a land where

> "The wind blows, oil flows, cotton grows, it never snows—
> And the shell collectors are all pros!"

Speaking of the unprecedented rains which had drenched the state in recent weeks, he said that he had been given to understand that thousands of years ago Corpus Christi had been 400 feet under water. "If present conditions continue we'll be right back down there! But don't you people allow rain or anything else to dampen your enthusiasm. Have a good meeting and let us know how any of us can help."

As he concluded Mayor Blackwell presented the key to the city to Anne Speers, the hardest working Texan of them all.

President Clarke added his own thanks to those of the Mayor for the hard work done by Mrs. Speers and her committees in laying the groundwork for the meeting. Though the AMU was visiting Texas for the first time, said Dr. Clarke, other malacologists were before us. "Lea, Dall, Strecker, Frierson—all worked on the mollusks of Texas."

He then introduced the first of the record number of 44 papers to be given on this and the subsequent four days:

ACTIVITIES OF *STROPHOCHEILUS OBLONGUS.* Ozro B. Wiswell, The University of Texas, Dental Branch, Houston. (see page 12)

SOME PHYSIOLOGICAL ASPECTS OF *STROPHOCHEILUS OBLONGUS.* Ozro B. Wiswell. (see page 43)

STUDIES ON THE DISTRIBUTION OF PRESUMED HEMAGLOBIN IN BIVALVE MOLLUSCA, Harold W. Harry, Texas A & M University, Marine Laboratory, Galveston. (see page 47)

SMALL BEGINNINGS, Adlai B. Wheel, Sr., Syracuse Boys' Club, Syracuse, New York.

This was a small boxed collection, the work of one of Captain Wheel's "problem" boys. His small boy-staffed museum is in constant need of material, a wonderful depository for surplus shells.

LARVAL DEVELOPMENT OF THE COMMENSAL BIVALVE *MONTACUTA PERCOMPRESSA*, Paul Chanley, Virginia Institute of Marine Science, Gloucester Point, Virginia. (see page 28)

DENSITY AND DISTRIBUTION OF THE SURF CLAM, *SPISULA SOLIDISSIMA*, John W. Ropes, U.S. Bureau of Commercial Fisheries, Biological Laboratory, Oxford, Maryland.

DENSITY AND DISTRIBUTION OF THE OCEAN QUAHOG, *ARCTICA ISLANDICA*, Arthur S. Merrill, U.S. Bureau of Commercial Fisheries, Biological Laboratory, Oxford, Maryland.

"Bring swim suit, collecting bag and big appetite!" These were instructions from the Coastal Bend Shell Club of Corpus Christi, sponsors of the Monday evening beach party. A motley crew of bearded pirates awaited their guests who arrived on Padre Island in chartered buses. While the fish fried and the beer cooled there was a rush to collect on the hard beach sand; *Ianthina janthina* and two species of *Hastula* were especially prized. These last had been the subject of a paper by Dr. Joe Morrison at the 1967 AMU meeting.

"Treasure hunt!" came the cry once the bounteous meal was over and away went the shellers, guided by clues at strategic points about the dunes. The treasures were bags of shells, kind fate decreeing that every seeker be a finder. The evening ended after a huge pyre of driftwood had burned down to the proper degree for toasting bushels of pirate-provided marshmallows.

Tuesday morning dawned clear and sunny. In fact, a benign weatherman had turned off the rain and throughout the meeting the temperature stayed in the high 80s while newspapers and television reported a record heat wave over the midwest.

At nine o'clock papers were resumed:

ESTABLISHMENT OF A TREMATODE CYCLE IN *TAREBIA GRANIFERA*, Harold D. Murray, Biology Department, Trinity University, San Antonio. (see page 17)

STUDIES IN THE LIFE HISTORY OF THE NAIAD *AMBLEMA PLICATA*, Carol B. Stein, Department of Natural History, The Ohio State Museum, Columbus, Ohio. (see page 46)

FORMATION, REGENERATION, PIGMENTATION AND LUMINOSITY, Lulu B. Siekman, St. Petersburg, Florida.

OBSERVATIONS ON WESTERN ATLANTIC CAECIDAE, Donald R. Moore, Institute of Marine Science, University of Miami, Miami, Florida. (see page 39)

MOLLUSKS OF PROJECT HOURGLASS, William G. Lyons, Florida Board of Conservation, Marine Laboratory, St. Petersburg, Florida. (see page 34)

NOTES ON PERIPLOMATIDAE (PELECYPODA, ANOMALODESMATA), Joseph Rosewater, Division of Mollusks, U.S. National Museum, Washington, D.C. (see page 37)

Conclusion of this paper signalled a muster about the fountain on the slope below the hotel where a group photograph was made. Following lunch the afternoon was given over to a Symposium on Rare and Endangered North American Mollusks. These collective papers will be published in their entirety in MALACOLOGIA.

ATLANTIC, CARIBBEAN AND GULF OF MEXICO MARINE MOLLUSKS, R. Tucker Abbott. Discussant: Joseph Rosewater.

PACIFIC MARINE MOLLUSKS, A. Myra Keen, read by William E. Old, Jr. Discussant, William K. Emerson.

BRACKISH-WATER MOLLUSKS, J. P. E. Morrison.

EASTERN FRESHWATER MOLLUSKS (1), David H. Stansbery.

EASTERN FRESHWATER MOLLUSKS (2), William H. Heard. Discussant, Arthur H. Clarke.

WESTERN FRESHWATER MOLLUSKS, Dwight W. Taylor; read by Harold D. Murray. Discussant, Harold D. Murray.

EASTERN LAND SNAILS, William J. Clench; read by M. K. Jacobson. Discussant, Dee S. Dundee.

WESTERN LAND SNAILS, Allyn G. Smith, read by Alan Solem. Discussant, Joseph C. Bequaert.

Following dinner and while the Executive Council met in annual session Myra Taylor conducted SHELL CLUB NIGHT at which time 23 delegates reported the past year's activities for as many shell clubs.

On Wednesday (mid-week already!) the following papers occupied most of the day:

ABUNDANCE, LOCAL VARIATION AND BROOD POUCH FORMATION IN *LIBERA FRATERCULA* FROM RAROTONGA, COOK ISLANDS, Alan Solem, Field Museum of Natural History, Chicago. (see page 10)

A "GASTROPOD" BIVALVE, COMMENSAL ON *SQUILLA EMPOSA*, Charles E. Jenner and Anne B. McCrary, University of North Carolina, Chapel Hill. (see page 20)

SPIROGLYPHICS—A STUDY IN SPECIES ASSOCIATIONS, Joseph P. E. Morrison, U.S. National Museum, Washington, D.C. (see page 45)

PYRIMIDINE CATABOLISM BY SOME GASTROPODS, Stephen H. Bishop, Baylor University College of Medicine, Houston. (see page 41)

MOLLUSKS OF EL PASO COUNTY, WESTERNMOST TEXAS, Artie Metcalf, University of Texas at El Paso. (see page 32)

NOTES ON CAPTIVE *CERITHIUM VARIABILE* AND *MITRA FLORIDANA*, Dorothy Raeihle, Elmhurst, New York. (see page 35)

A COLLECTION OF MARINE MOLLUSCA FROM THE NORTHWESTERN PART OF THE GULF OF MEXICO, Helmer Odé, Bellaire, Texas. (see page 16)

OBSERVATIONS ON *ROSENIA NIDORUM* (Pilsbry) AND *ARENE SOCORROENSIS* (Strong). Donald R. Shasky, Redlands, California.

THE MARINE MOLLUSKS OF THE MARQUESAS ISLANDS, Harald A. Rehder, U.S. National Museum, Washington, D.C. (see page 29)

HETERODONT AFFINITIES OF THE LUCINACEA, Kenneth J. Boss, Museum of Comparative Zoology, Harvard University. (Read by M. K. Jacobson.) (see page 21)

LITERARY MOLLUSKS, Morris K. Jacobson, Rockaway, New York. (see page 29)

Into buses at 4:30 and a 30 mile ride to the Welder Wildlife Foundation and Ranch where a real life sized Texas Bar-B-Q was underway. Beef and cabrito had been on the huge grill since noon and few passed up the latter even when informed by those in the know that cabrito was young goat.

A tour of the large wildlife preserve included a stop at the attractive small museum whose flower borders were thoroughly combed for shells. (*Bulimulus dealbatus* and a small polygyrid.)

As darkness fell a duo of musicians donned Texas-sized sombreros and guitars, distributed song sheets and led a singalong the like of which has never been known in malacological circles. Although the Houston Conchological Group had been responsible for the enjoyable affair it was a bit startling to discover the heretofore hidden talents of one of the musicians, none other than AMU Past President Tom Pulley.

On Thursday the remainder of the papers were heard:

MORE ABOUT INTRODUCED MOLLUSKS, Dee S. Dundee, Louisiana State University in New Orleans.

SOME FAUNAL-FLORAL-SUBSTRATE INTER-RELATIONSHIPS AT LOW TIDE, Fay H. Wolfson, San Diego, California, Natural History Museum.

ECOLOGY AND DISTRIBUTION OF THE MICRO-MOLLUSKS OF THE LAGUNA DE TAMIAHUA, VERACRUZ, MEXICO, Antonio García-Cubas, Universidad Nacional Autónoma, Ciudad Universitaria, Mexico. (Read by Donald Shasky.) (see page 17)

BIOLOGICAL STUDIES IN THE TEREDINIDAE, Ruth D. Turner and A. C. Johnson, Museum of Comparative Zoology, Harvard University. (Read by Kay Lawrence.) (see page 14)

SEXUAL DIMORPHISM IN ERYCINACEAN BIVALVES, Charles E. Jenner and Anne B. McCrary, University of North Carolina, Chapel Hill.

INTERESTING MOLLUSKS FROM BRAZILIAN FISHES, William E. Old, Jr., American Museum of Natural History, New York City.

REMARKS ON THE CUBAN GENERA OF VIANINAE, Morris K. Jacobson, Rockaway, New York. (see page 40)

PREVENTION OF REAGGREGATION OF DISAGGREGATED MOLLUSCAN CELLS, Vera King Farris, Museum of Zoology, University of Michigan, Ann Arbor. (see page 42)

REAGGREGATION OF MULTIPLE ORGANS FROM DISSOCIATED MOLLUSCAN CELLS, Vera King Farris. (see page 33)

ANALYSIS OF QUANTITATIVE RECORDS OF MOLLUSCA IN PLEISTOCENE LAKES OF OHIO, Aurèle LaRocque, Ohio State University, Columbus, Ohio. (see page 13)

EVOLUTION AND TAXONOMIC REVOLUTION IN THE LYMNAEIDAE, Harold J. Walter, Dayton, Ohio. (see page 18)

This final paper was concluded at 3:30 P.M. and following a short break President Clarke called the annual business meeting to order.

Reading of the Minutes of the previous business meeting was waived since they had been published in the 1967 Report Bulletin.

The Secretary was asked for a report on the 1967 activities of her office:

On December 31, 1967 total AMU membership stood at 754, three fewer than during the previous year. 102 new members were enrolled, 86 dropped for delinquent dues, 13 resigned and six died. Memberships were divided into the following categories:

460 regular, 187 family, 131 Pacific Division, 42 shell clubs, 36 corresponding, 22 paid life, 6 honorary life, one life president.

In the first six months of 1968 67 new members have applied and been enrolled while five have died: James B. Gross, William F. White, Roy Morrison, V. D. P. Spicer and Fred Tobleman. These last three were charter members.

No especial effort has been made to increase membership. Application forms are sent only on request or, in some instances, included with information requested by those with university or museum addresses. Usually this results in a new member who may be expected to remain on the AMU roster, not the case with those with but a cursory interest in the science.

700 copies of the 1967 Report Bulletin were printed and 657 mailed out on March 18 at a per copy cost of $2.83. This included printing and enclosure of the 1968 statements and a preliminary announcement of the July meeting at Corpus Christi.

248 copies of How to Collect Shells were sold in 1967 for $442.61. Since the supply on hand will be depleted before 1969 Dr. Tucker Abbott has volunteered to arrange for printing 1000 copies—this in June, 1968. He estimates a per copy cost of about 75 or 80 cents since the type for the previous meeting has been allowed to stand. This will provide a much greater profit in future sales.

An estimated one thousand letters were answered in 1967; they ranged from, "Tell me all about shells" and "Send me everything that's free" to "Please, I need about fifteen hundred words on the subject of the pearl oyster." Fewer than one in ten include return postage, accounting for the high cost of stamps in the secretary's budget.

It was moved, seconded and carried that this report be approved as read.

Unable to be present, Treasurer Baker had prepared a report of her office covering the first six months of 1968; it was read by the Secretary:

Report of the Treasurer for the six months ending June 30, 1968.
Receipts:

Memberships: Individual	$1318.25	
Shell Clubs	180.00	
Sales of How to Collect Shells	222.84	
Pacific Assessments	27.30	
Interest on Savings Certifs.	100.39	
Sale of Back Reports	18.00	
Exchange collected	1.00	
Total Receipts		$1867.78
Savings Certificate cashed		1000.00
Balance, Jan. 1, 1968		412.74
Total cash to be accounted for		3280.52
Disbursements:		
Annual Report, 1967	$1990.60	
Postage—Sec., Treas., Publ. Ed.	82.75	
Printing, except report	49.00	
Mimeographing—Sec.	27.81	
Office Supplies—Sec., & Treas.	36.15	
Advance for 1968 meeting	25.00	
Dues to AAAS	10.00	
Misc. Expense	8.40	
Bank Charges	19.67	
Adv't for HTCS	6.39	
Pac. Assess. pd to PD Treas.	26.80	
Total Disbursements		$2282.57
Cash Balance, Checking acc't, June 30, '68		997.95
Total cash accounted for		3280.52

Assets:		*Liabilities:*	
Cash—Checking acc't	$ 997.95	Life Membership Fund	$1410.88
Petty cash—Treas.	10.00	NET WORTH, July 1, 1968	3395.87
" " —Sec.	100.00	(1967 net worth $3599.50)	
5% Savings Certificates	3000.00		
Savings Account	698.80		
TOTAL ASSETS	$4806.75		

To be noted from above report:

The cost of the Annual Report alone exceeded by about $123 the total receipts. In fact its cost was about $500 more than monies received from

memberships. The Treasurer feels that these two figures ought to balance within a few dollars. The total of the Net Worth of the organization has dropped over $200. I anticipate a further drop as we pay expenses of the 1968 meeting and for the reprinting of "HTCS." The latter will, of course, eventually pay for itself, but some receipts should be laid aside for further printing of that or other publications of the AMU. Since the major part of the income for the year has now been received, and since major expenses are still to be met, again I strongly urge that dues be raised. The long and involved process set forth in the Constitution should be started now if dues are to be raised by 1970.

Respectfully submitted,

Bernadine B. Baker, Treasurer

It was moved, seconded and carried that this report be approved as read.

The Secretary was asked to report briefly on action taken by the Executive Council at the July 16, 1968 meeting of that body. Council had:

Heard and approved Minutes of the previous meeting of the AMU Executive Council;

Heard and approved the report of the AMU Treasurer;

Heard and discussed invitations to hold the 1969 AMU meeting in Key West, Florida, Phoenix, Arizona and Marinette, Wisconsin. The latter invitation was accepted, the former two held in abeyance for consideration another year;

Heard reading of the Minutes of the 1968 business meeting of the AMU, Pacific Division;

Approved deletion of Article 4, Section 3 of the AMU Constitution which affects control of AMU over certain Pacific Division By-laws;

Discussed advisability of substantially increasing AMU membership;

Discussed desirability of holding every other meeting of the AMU in Pacific Division territory (i.e., the west coast);

Discussed and tabled the suggestion of publishing a bi-monthly or quarterly newsletter;

Recommended raising annual dues from $3 to $4 per year (this will require a Constitutional change and will be voted upon by the membership at large before the 1969 meeting);

Approved the motion that Symposium papers on rare and endangered molluscan species be published in their entirety in MALACOLOGIA and as abstracts in the 1968 Annual Report Bulletin.

Heard and gave unanimous endorsement to the slate of nominated officers;

Adjourned.

Ratification of these actions was signified by majority voice vote of the members present.

President Clarke announced that a paper had been circulated wherein Dr. A. Myra Keen has been recommended for Honorary Life Membership. It bore the necessary ten signatures. The Executive Council signified approval in a standing vote and the action was made final as the members present voted a unanimous "Aye."

Vice-president Joseph Rosewater rose to read a resolution wherein the

AMU extended a warm welcome and all good wishes to the recently organized Western Society of Malacologists.

President Clarke called for the report of the Nominating Committee and Chairman William K. Emerson read the following slate to fill the chairs in 1968–69:

President, Joseph Rosewater;
Vice-president, Alan Solem;
2nd Vice-president, G. Bruce Campbell;
Secretary, Margaret C. Teskey;
Treasurer, Mrs. H. B. Baker;
Publications Editor, Morris K. Jacobson;

Councillors-at-Large:
Donald R. Moore,
Robert Robertson,
Donald R. Shasky,
Myra Taylor.

Motion was made from the floor that the nominations be closed, a second motion was made that the Secretary be instructed to cast a unanimous vote for the slate as read. Seconded, carried.

There being no further business it was moved, seconded and carried that the 1968 Business Meeting stand adjourned.

The final hour was given over to an unscheduled showing of slides in pleasant contrast to the heavy going of the past four days. Especially appreciated was a pictured collection of Amphineura; anyone who had thought of chitons as drab creatures of little interest was quickly disillusioned as one beautiful slide followed another.

Then it was time to dress for the annual dinner, always a pleasant occasion. The speakers have banished their butterflies and are prepared to enjoy the evening, the ladies' party finery adds an air of festivity and the fact that another successful meeting is nearly over brings relaxation and increased fellowship to this traditionally friendly organization.

The setting for the social hour which preceded the banquet was the beautiful third floor patio surrounding the hotel swimming pool. There as the sun set across the harbor, members of the South Padre Island Shell Club dispensed punch and hors d'oeuvres while strolling sombreroed musicians continued the air of Fiesta.

Piñatas in the form of parrots and fish hung from the balconies above and one blindfolded guest after another was spun about, then given a stick with which to break the candy-filled containers. One huge paper donkey and rider was not demolished, but was later awarded as a prize during the banquet.

The buffet style meal offered all of the seafoods for which the area is famous augmented by a huge roast of beef. As diners bore heaped plates to the several long tables it was to discover as individual place favors vials containing a specimen of *Polygyra hippocrepis* (Pfeiffer) 1848. The small (11 mm) mollusk is remarkable for having survived for over a century in an exceedingly limited range. It lives today only where Pfeiffer found it, near New Braunfels, Comal County, Texas.

However, since these were living specimens and presented to more than one hundred delegates from nearly as many localities, is it not possible that during the next century the range of *P. hippocrepis* may be considerably extended?

The San Antonio Shell Club was the official host now and had planned well for the hours following dinner. First came awarding of several tokens

in addition to the place favors; besides the donkey piñata, table decorations of imported Mexican tinware were given to those lucky persons who found a star pasted beneath their coffee saucers.

Dr. Clarke then rose to perform his final duties as AMU President. He introduced those seated at the head table, including Mayor and Mrs. Blackwell, the AMU Past Presidents, finally the two sparkplugs most responsible for the success of the meeting, Anne Speers and Myra Taylor.

Mrs. Speers and Mrs. Taylor in turn introduced their husbands, their committees and finally asked all of the members of the six Texas shell clubs to stand and be recognized. Prolonged applause came from their guests in tribute for a job well done.

Dr. Clarke then introduced the evening's featured speaker, Dr. Thomas E. Pulley of the Houston Museum of Natural Science. His topic, TROPICAL REEFS OF TEXAS.

In 1961 during the AMU meeting in Washington, D.C. he had reported on the recent discovery of a living coral reef in the Gulf of Mexico, 125 miles off Galveston, Texas. This hour-long color film chronicled a recent diving expedition to what has become known as Flower Garden Reefs, when, aided by thirty amateur divers and a Navy destroyer the Houston Museum of Natural Science had conducted extensive exploration. It was a beautiful picture, ended all too soon and at its conclusion Dr. Pulley answered questions fired from all parts of the room.

Dr. Clarke then presented the gavel to the new President, Dr. Joseph Rosewater; he in turn thanked everyone who contributed to the success of the meeting and declared the meeting adjourned.

Friday was field trip day. At 9:30 three separate safaris set off, one to Corpus Christi Lake for freshwater clams and snails, a second to various nearby sites for land species, and the largest group left in two buses for Mustang Island and the Gulf beaches.

All returned at varying times reporting as many degrees of success or failure, dirty, tired and happy. Some checked out at once, others stayed until the following morning.

Saturday, July 20, 1968 was getaway day. On Sunday, July 20, 1969 we shall meet again, this time in Wisconsin. Skoal!

Margaret C. Teskey, Secretary
American Malacological Union, Inc.

ABSTRACTS AND CONDENSED PAPERS READ AT THE 1968 ANNUAL MEETING, AMERICAN MALACOLOGICAL UNION

ABUNDANCE, LOCAL VARIATION AND BROOD POUCH FORMATION IN *LIBERA FRATERCULA* FROM RAROTONGA, COOK ISLANDS

Alan Solem

Field Museum of Natural History, Chicago, Illinois

Pacific Island land snails of the subfamily Endodontinae commonly deposit their eggs within the widely open shell umbilicus. Secondary narrowing of the umbilicus to form a globose or elongately-globose "brood pouch" has occurred independently in several different island groups. Each time the umbilical narrowing is achieved by inward growth of the lower whorls, but the mechanics of closure vary in each case.

The Cook Island species, *Libera fratercula* (Pease, 1864) has the juvenile shell (fig. 1) with a typically rounded columellar-basal margin. Increasing angulation of this margin is accompanied by gradual anterior inclination of the columellar lip edge and then inward growth of the entire columellar wall. A much tighter coiling pattern is obtained by reducing the outward growth vector through deflection and provides needed elongation of the umbilical cavity. These changes combine to narrow the umbilical opening drastically (fig. 2), and result in an elongately-ovate cavity with very narrow external opening.

In all other known Endodontinine species with umbilical brood pouches, the young exit through the narrowed umbilical opening, chewing the internal margins as needed if the exit hole is too small. *Libera fratercula* is unique both in habitat and method of juvenile emergence. All other Pacific island Endodontinae are restricted to areas of undisturbed native forest or upland moss forest areas. They will not live in ecologically disturbed areas and are now extinct in most lowland localities. *Libera fratercula* lives in disturbed lowland scrub within about 150 yards of the shoreline under the coral rubble cast up during severe storms. As the accumulation of rubble decreases, the snail population density is reduced. After the rubble zone ends, there are no more *Libera* present.

Living with a superabundance of lime, *Libera fratercula* has evolved into a profligate user of calcium. As the process of umbilical narrowing takes place, the soft parts gradually withdraw from the apical whorls, filling the cavity with calcium. Juveniles hatch and slowly chew their way outwards and upwards, eventually exiting through or near the shell apex (fig. 3). During this process, the adult snail continues to live. It can survive for an undetermined time after the juvenile emergence is completed. The deliberate complete filling of the early whorl cavity and total directional reversal of juvenile "rock chewing" provide a most remarkable pair of behavioral alterations. Only one reproductive cycle is possible for an individual snail, since the apical exit hole could not be repaired.

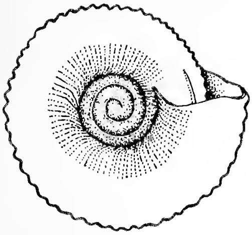

Fig. 1

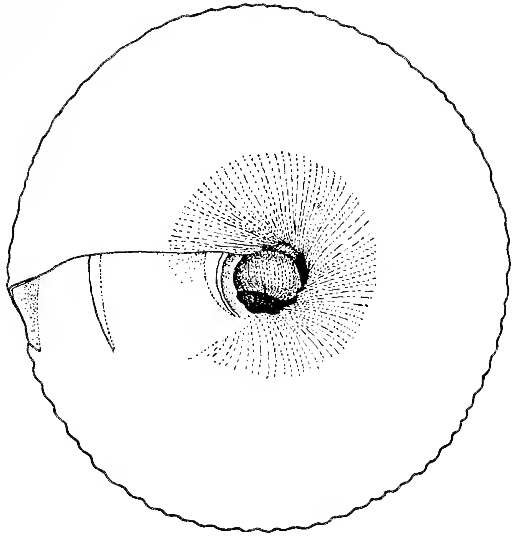

Fig. 2

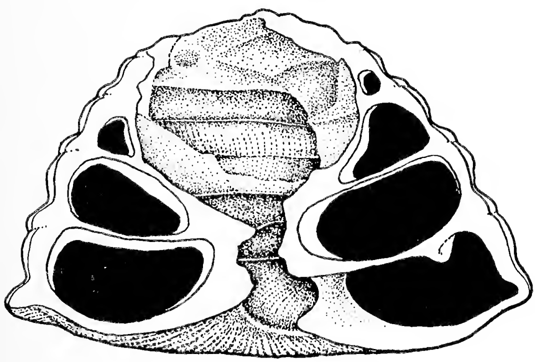

Fig. 3

Libera fratercula (Pease)

2 mm

Although living in a narrow habitat, *Libera fratercula* is quite abundant. A colony located 1.6–2.8 miles north of Avarua on Rarotonga was semiquantitatively analyzed by taking centrally located quadrats at 200 yard intervals. Each quadrat was 15 inches on a side. Ten samples contained from 33 to 92 living specimens, with a mean of 62.3. This is equivalent to 39.9 ± 3.5 live snails per square foot, or 1,737,000 snails per acre. The portion of this colony between the coastal road and strand line contained about 43,000,000 live snails in early December 1965. Not only does this colony continue inland of the road for up to 100 yards, but there are several other large colonies elsewhere on Rarotonga and its satellite islands. The total living individuals must be several times the 43,000,000 estimated for part of one colony.

For all ten samples, the proportion of adults was 62.4%, of juveniles 37.6%. Within each sample, the proportion of juveniles varied from 5.7% to 66.1%. Adult size and shape also varied significantly between samples, although showing a normal distribution when the samples are lumped. There was no correlation between size and percentage of adults, since the four samples with the highest percentage of adults included the two largest and two smallest in mean diameter.

Reproductive condition of each adult was determined as one of four categories: prereproductive (no eggs in brood pouch, 46.5%); eggs in brood pouch (1.5%); young in brood pouch (44.5%); and post-reproductive (young emerged through apex, 7.5%). Percentage distribution within samples varied dramatically: prereproductive from 21.4–86.1% with the extremes in adjacent quadrats; eggs were present only in one sample; young present in 4–78.6%; and post-reproductive in 0–30%. No pattern was evident, those samples with most post-reproductive individuals having fewest juveniles, rather than the expected large number.

The habitat of *Libera fratercula* is subject to two predictably erratic forms of major disturbance: 1) occasional major storms that drown part of a colony and toss up additional rubble; and 2) short to intermediate term droughts that dry out the habitat at irregular intervals. By having segments of a colony in different phases of the reproductive cycle simultaneously, some parts always will be in the phase best suited to survive stress of storm or drought whenever such might occur. The surviving snails would be aggregated and able to rapidly recolonize adjacent depleted zones.

Field work to test this hypothesis and investigate queries raised by this preliminary study is planned. This project was supported by National Science Foundation grants GB-3384 and GB-6779.

ACTIVITIES OF THE *STROPHOCHEILUS OBLONGUS*[1]

Ozro B. Wiswell and Henry C. Browning
Department of Anatomy
The University of Texas Dental Branch at Houston, Texas

The first colony of *Strophocheilus oblongus*, a giant South American snail, has been established in the United States. The original adults were imported

[1] Supported by U.S.P.H.S. General Research Support Grant FR-5344.

from Porto Alegre, Brazil, arriving in Houston, Texas by air express on 28 September 1966.

The *Strophoceilus oblongus* is a large, phytophagic, hermaphroditic terrestrial gastropod. The original adults in this colony weighed between 70–100 gms; their shells (univalve), from anterior mantle edge to umbo, measured 7.5–10 cm; and the foot, when extended in locomotion, is 12–15 cm long.

An apparent adequate diet has been established in that over 500 eggs have been produced and to date over 300 have hatched. By timed matings, egg maturation time is 19–20 days and incubation at 21.1° ± 1° C is about 53 days.

This color motion picture portrays activities of the *Strophocheilus oblongus* from estivation, mating, phytophagy, egg hatching, and other physiologic activities.

This film portrays activities of the first going colony of *Strophocheilus oblongus* in North America.

ANALYSIS OF QUANTITATIVE RECORDS OF MOLLUSCA IN PLEISTOCENE LAKES OF OHIO

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Summary

For more than fifteen years methodical collections of Mollusca have been made from some twenty different lake deposits situated from one end of Ohio to the other. Similar, but less extensive, studies have been made in Wisconsin, Ontario, and Quebec. The collecting has been done according to a uniform plan described elsewhere (*Pleistocene Mollusca of Ohio*, 1966, Part 1, p. 7–9) and have been studied by some ten graduate students of the writer, each concentrating on one deposit at a time. Their work has yielded data on the changing abundance of each species represented from its first appearance in the sediments to the top of the deposit. The lake faunas are marked by a certain degree of uniformity in the number and nature of the species represented. It is therefore possible to compare the fluctuations of each species in various deposits from the latitude of Ohio to that of the Gaspé Peninsula of Quebec. The most obvious result of these comparisons is that within a given deposit there is negative correlation between groups of species so that increasing abundance in one group corresponds to decreasing numbers in another.

The next question to invite answer is whether these group of species behave in the same way in all deposits and whether there is any relationship between these fluctuations and other known factors, for example changes in lithology of the sediments, changing depth of water, changing abundance of vegetation, or other less obvious factors.

In the next phase, biometric analysis of samples of each species in stratigraphic sequence will be examined for possible significance in terms of population genetics.

The results of these studies, now in progress at Ohio State University, should be of interest for ecologists and paleoecologists.

BIOLOGICAL STUDIES IN MARINE WOOD BORERS

R. D. Turner[1] and A. C. Johnson[2]

Recent systematic and anatomical work on the Teredinidae (Turner, 1966) indicated that further research on the biology and life history of these specialized wood borers was greatly needed. Therefore, during the past three years we have been working with these animals on a broad basis, taking advantage of the material available in as many ways as possible. We have had three working periods in the field, one at the W. F. Clapp Laboratories, Duxbury, Mass. (June–September 1966) and two at the Institute of Marine Science Laboratory, La Parguera, Puerto Rico (March–June 1967 and December 1967–March 1968). Eight species of Teredinidae are found in the vicinity of La Parguera and observations were made on all of them. Our particular interest was in studying the length of the free swimming larval life and the behavior of the larvae at the time of settlement. We worked with three species of *Teredo* which release the young as pediveligers, two species of *Lyrodus* which release the young in the straight-hinge stage, and three species, *Nototeredo knoxi* (Bartsch) and *Teredora malleolus* (Turton), family Teredinidae, and *Martesia striata* (Linné), family Pholadidae, which spawn eggs and sperm so that the entire development takes place in the sea. To be sure of the species with which we were working, adult animals were dissected from the wood and spawned in petri dishes. The males and females of the oviparous species were kept in separate dishes, the eggs and sperm being removed immediately they were spawned. The eggs were placed in large beakers of filtered sea water and a small amount of sperm was added. A sample of the culture was watched under the compound microscope to ascertain the time scale of development to the straight hinge stage. Photographs and measurements were made of the various stages.

Free swimming straight-hinge veligers, of both oviparous and larviparous species require feeding. Though the larvae we were rearing grew somewhat they did not reach the pediveliger stage because of lack of proper food. However, it is quite evident that the duration of the straight-hinge stage is dependent on food and that it can be extended for a considerable period if food is scarce, a factor which may be very important in dispersal.

Young borers released as pediveligers do not require feeding and can be immediately exposed to wood. In experiments to determine how long the pediveligers could survive in the plankton, the brood from a single specimen of *Teredo furcifera* von Martens was divided into five groups; one lot was immediately exposed to wood in a 'micro-aquarium'. The others were held in beakers for three, seven, seventeen days and until all the veligers had stopped swimming and were crawling or resting on the bottom of the beaker (22 days). Several specimens of all groups successfully penetrated the wood. The length of time which the larvae spent crawling on the surface decreased in relation to the time they were kept in the beakers, a phenomenon particularly noticeable with the 17 and 22 day groups. Since experiments with *Teredo clappi* Bartsch had similar results, the presence of wood may trigger

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settlement and metamorphosis; however, the veligers of at least these two species can remain in the plankton much longer than had been expected and still be capable of penetrating wood.

In order to observe and photograph the larvae without disturbing them, special 'micro-aquaria' were made using 100×22 mm disposable petri dishes with a disc of white pine about 8 mm thick fastened to the bottom. The fine end of a pipette was inserted through a small hole made near the upper edge of the dish and was held in place with 'clear-seal' (a non-toxic silicon cement which remains flexible). A series of these 'micro-aquaria' were connected by plastic tubing to a large tube which in turn was connected to the running sea-water system through a 15μ filter. The flow of water into each of the micro-aquaria could be controlled separately allowing a sufficient flow for aeration and feeding but not enough to disturb the larvae. Observations and photographs were made with a Leitz compound microscope mounted on a special pillar stand using an ultropak illuminator and dipping cones. The microscope, on a separate small table, could be moved along the length of the small water table holding the 'micro-aquaria' so that one had only to remove the cover from the petri dish, lower the dipping cones and observations could be made with the minimum of disturbance.

One of the major problems in working on the biology of the Teredinidae has been the difficulty of keeping the animals alive outside of the wood; therefore we did some preliminary experiments and were particularly successful with *Nototeredo knoxi* (Bartsch). Some specimens partially exposed lived for several days, and one, whose valves were not completely exposed even continued boring. After two days, however, they produced a thin, opaque calcareous tube so that it was no longer possible to observe them. Other specimens were completely dissected from the wood, great care being taken not to damage the mantle. The specimens were placed in petri dishes (not more than two per dish) and the water (which had been passed through a 15μ filter) was changed daily. These specimens lived for over three weeks. They all built calcareous tubes around the base of the siphons and some glued themselves to the bottom of the dish at this point. After a week in the petri dishes some of the specimens spawned quite normally, producing viable eggs and sperm. It was possible to feed these specimens with finely powdered cellulose (the type used in making cellulose agar) by placing it on the foot near the mantle collar. Cellulose dyed with congo red could be traced through the gut and red fecal pellets were produced. Other animals were starved until they no longer produced fecal pellets. Plankton, concentrated from sea water run through the 15μ filter, added to the dishes, was taken in through the incurrent siphon and small fecal pellets were produced.

Injured specimens usually were discarded immediately but one, which had been cut in two some distance anterior to the siphons, was accidentally kept. The following day it had closed off the cut end and appeared in good condition, the heart beating quite normally. In 11 days it had developed an abnormal, but functional incurrent siphon. Though repair of the tube, pallets and the tips of the siphons occurs regularly in the Teredinidae, regeneration of this magnitude is unusual, being nearly equivalent to the regeneration of the proboscis in some gastropods (Carriker, 1961).

As these animals are nearly transparent, the transport of food through the gut, the functioning of the heart which is relatively very large, and the re-

lease of the reproductive products can often be observed without dissection. They should, therefore, prove to be ideal experimental animals.

This work was done with the aid of a contract from the Office of Naval Research, NR: 104-689, 1866(45) with Harvard University. We are most grateful to Dr. J. Blake, W. F. Clapp Laboratories, Duxbury, Massachusetts and Dr. M. Cerame Vivas, Institute of Marine Science, University of Puerto Rico, Mayagüez for the privilege of working in their laboratories. Experiments are now also being conducted at the Marine Science Institute, Northeastern University at Nahant, Massachusetts and we wish to thank Dr. Riser for the privilege of working there.

A COLLECTION OF MARINE MOLLUSCA FROM THE NORTHWESTERN PART OF THE GULF OF MEXICO

Helmer Odé
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The molluscan fauna of the northwestern part of the Gulf of Mexico is not as well known as that of other parts of the Atlantic coastline of the United States of America.

About five years ago Dr. H. Geis took the initiative in organising a systematic survey of the molluscan fauna of the shelf area extending in front of the Texas coast. An agreement with Dr. T. Pulley, director of the Houston Museum of Natural Science and with the Bureau of Commercial Fisheries in Galveston, was reached, according to which the Bureau would furnish samples of bottom fauna, which then would be processed under supervision of Dr. Geis and myself by members of the Houston Shell Club. Each sample was washed in fresh water, and dried and sieved. The small fraction was picked in its entirety under the microscope. All samples were then sorted into lots and doubly catalogued with appropriate data.

We hope that this collection may serve a double purpose: to provide more data about the fauna of the least known area of the Gulf of Mexico and secondly to make available a wealth of material from a rather extensive area in which many different ecologies occur.

In so large an area as the Texas offshore many sample locations will be required. At present most of our approximately 250 locations are in the Galveston-Freeport area. At a conservative estimate this material contains over 1200 different species divided over more than 10,000 lots. Most samples have been collected in water less than 50 fms. To get an adequate representation of the fauna about three times as many locations will be required especially many from the southern part of the Texas Coast.

The results so far are most gratifying. A fauna rich in pyramidellids, leptonids, and vitrinellids, mainly belonging to the Carolinian province was uncovered on the shelf. Material from the offshore coral reefs near the continental slope is especially interesting in that it shows the presence of a purely Caribbean fauna, containing many species hitherto unreported so far to the northwest: *Spirolaxis, Malleus, Condylocardia, Strombus gigas.* Two specimens of *Haliotis pourtalesi* were obtained (dead shells) from the in-

ternal cavity of a sponge brought up by scuba divers from a depth of 24 fathoms.

It is our hope that all workers in the field of malacology will avail themselves of this collection which is housed in the Museum of Natural Science in Houston.

ECOLOGY AND DISTRIBUTION OF THE MICRO-MOLLUSKS OF THE LAGUNA DE TAMIAHUA, VERACRUZ, MEXICO

Antonio García-Cubas
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Remarks. (Morrison) I would like to comment on this very important work. Since I was in the field with Dr. García-Cubas in the region of the Laguna de Terminos, Campeche, I know how very fundamental these studies are. Even if the primary concern of the Institute of Geology of the National University of Mexico is study of sedimentation in the Tamiahua Lagoon, the species of shells involved in such lagoon evolution and sedimentation must be surveyed and identified. This and similar future studies become most valuable (from our point of view) by the complete collections and listings of the molluscan shells from all the salt and brackish water zones of each lagoon. I suspect that in the future the molluscan fauna of all the freshwaters tributary to each lagoon system of Mexico will also be intensively studied. There are still undeveloped human food resources in these waters, just as there are in United States waters.

ESTABLISHMENT OF A TREMATODE CYCLE IN *TAREBIA GRANIFERA* (LAMARCK) IN TEXAS

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(Summary)

In 1952 R. Tucker Abbott reported, in the Proceedings of the U. S. National Museum, the occurrence of *Tarebia* (= *Thiara*) *granifera* in Lithia Spring, Hillsborough County, Florida, at which time he noted that dissected specimens showed no evidence of trematode infection. *T. granifera* is a known intermediate host for several trematode parasites of man and other vertebrates in the Orient, notably the parasites *Metagonimus yokogawai* and *Paragonimus westermani*.

In 1964 H. Murray reported to the AMU Convention on the occurrence of both *T. granifera* and *Melanoides tuberculatus* in South Texas. Both species of snails were introduced to the United States from the Orient. In the 1964 report it was noted that the occurrence of these snails in the effluent from the San Antonio Zoo was of particular importance. Because the zoo maintains numerous exotic birds, native birds, and many animals, the presence of these snails in association with the zoo animals increased the possibility of a trematode cycle being established.

In 1965 Leon Wopschall and H. Murray reported to the AMU Convention on *T. granifera* and *M. tuberculatus* concerning the numbers of snails, the fluctuations of the populations, and the composition of the populations in Texas. Again, attention was called to the possibility of the establishment of a trematode cycle particularly in relation to the high numbers of snails which averaged 4,798 living snails per square foot. The combined high numbers of snails and high numbers of exotic animals within the zoo established an unrealized but potential problem.

From 1965 to the present periodic but unsystematic checks have been made for trematode infections in both *T. granifera* and *M. tuberculatus.* In April 1968 Alderus Stewart was preparing routine slides of gonadal tissue of *T. granifera* at which time he obtained four trematode rediae from the digestive gland of the snail. Examination of the somewhat poorly prepared material showed the rediae to be mature rediae bearing numerous cercariae. This is, as best as we can determine, the first record of *T. granifera* being naturally involved in a trematode life cycle in the United States.

At present, the trematode is not identified except to note that it has a distome cercaria. The following are noted concerning this infection:

1) Up to the present, no sporocysts have been observed.
2) A total of 35 rediae have been observed in 10 snails.
3) No cercariae have hatched in the laboratory and none have been recovered from the effluent waters.
4) The cercariae are not of the genus *Schistosoma* but probably of the family Echinostomatidae.
5) The infection of *T. granifera* appears to be light, with approximately one out of every 30 snails having rediae; however, snails located downstream from the zoo show no infection.
6) All rediae have been located in the basal ½ of the digestive gland.
7) The veterinarian staff of the San Antonio Zoo has no knowledge of pathologic conditions due to trematode infections for any animal in the zoo.

Any conclusions at this time are purely speculative; however, because the infected snails are close to the zoo and because the greatest concentration of numerous species of birds also occurs in this same area, it is possible that this is an avian trematode.

EVOLUTION, TAXONOMIC REVOLUTION, AND ZOOGEOGRAPHY OF THE LYMNAEIDAE[1]

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A series of anatomical types corresponding to an amazingly complete evolutionary sequence has been identified among lymnaeids. Knowledge of radulae, egg-masses, and chromosome numbers correlates remarkably well with that sequence, but shell characters do so only in a special broad sense.

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Detailed analysis of voluminous data reveals a zoogeographic pattern resembling the classic one in which more primitive forms occur southward in the Old World, far from boreal centers of speciation. All generic and subgeneric subdivisions of the family, including *"Lanx,"* are untenable. Various species of concern need nomenclatorial clarification; the given references indicate why certain names are used below.

In the rise of the "higher" Lymnaeidae, the primary anatomical changes evidently were: reduction of the ancestrally long and simple penis to an almost vestigial state, and its re-evolution, with acquisition of a penial knot, and radial and other special musculature, as part of a copulatory holdfast mechanism; narrowing of the vagina proper, and its acquisition of a powerful sphincter, as part of that mechanism; loss and re-evolution of the uterine caecum; enlargement, then reduction, of the prostatic tract, its change from a unifolded to a multifolded condition, then reversion to the former condition, its sharp division into 2 "prostates," and finally, rapid development of a prostate pouch. Concurrent trends affected muscularity, glandularity, conformity, and size of the reproductive organs as a whole. Evidently, reversions are important in lymnaeid evolution, producing chimaeras which look like intergeneric hybrids, and giving the impression that the phylogenetic pattern is reticulate.

The identified morphological types, in their proposed evolutionary sequence, are: radicine, prostagnicoline, and, primitive, intermediate, and advanced, stagnicoline. In corresponding order, they are represented by: *"Radix ollula"* (having a *"Fossaria"* shell), *"R. luteola," "Stagnicola corvus"* (from Sweden and Poland), *Lymnaea sp.* (from England: conchologically, *"S. palustris"*), and *L. catascopium.* This sequence is indicative of a phylogenetic main-stem, connecting the ancestral lymnaeid stock with the most progressive modern stock. Existing species-groups largely seem to represent adaptive radiations that occurred at the indicated levels.

At least 5 species, and perhaps 20 or more, representing all of the above morphological types, are conchologically masquerading in Eurasia as *L. palustris.* Among them, there appears to be a *"procatascopium"* group spread from central Europe to Siberia. However, only one fully advanced species is known from the Old World; described from Poland as *Galba occulta* Jackiewicz, it may be introduced *L. caperata.*

L. stagnalis is very closely allied to *"L. corvus"*; *"L. omsiana"* of south-central Asia may be largely transitional between them. Except for *L. stagnalis* and *L. atkaensis,* all stagnicolines in America are of the advanced type. The last-named species is a *"stagnalis-catascopium"* chimaera, internally.

L. catascopium evidently arose in North America, by the mid-Pliocene, with a *"palustris"* shell; while becoming conchologically highly polymorphic, as it spread over most of that continent into diverse habitats, it has remained exceedingly constant anatomically. I contend that it gave rise to *L. attenuata, "Acella,"* and *"Lanx"*; also to *L. aulacospira, "Erinna"* (both of a pro-*"Lanx"* stock?), the sinistral lymnaeids, and another species, of Hawaii; and, to *L.*

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caperata. The latter may belong to a species-complex, including "*L. occulta,*" ranging from South America to Alaska, Greenland, and Europe.

Species of "*Fossaria,*" "*Bakerilymnaea*" (or, "*Nasonia*"), and "*Leptolimnaea*" are of a simple, uniform anatomical type; they, with the similarly simplistic yet divergent "*Bulimnaea*" and "*Pseudosuccinea,*" heterogeneously show characters indicative of prostagnicoline affinities. Certain "conchological *Radixes*" of Eurasia apparently have stagnicoline anatomical tendencies, but "*Omia*" and the succiniform African radicines do not. Among the latter, species having a special structure at the female pore include one from South Africa reported to me (by J. A. van Eeden) to have quadricuspid lateral teeth!

While the ancestral home and evolutionary center of the family perhaps was North America, the "*procatascopium*" stock that produced the higher Lymnaeidae possibly came from the Old World via the Bering passage.

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A "GASTROPOD" BIVALVE, COMMENSAL ON *SQUILLA EMPUSA*

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In 1855, William Stimpson gave a brief account of *Lepton longipes,* a remarkable bivalve mollusk from the South Carolina coast, which he described as "gastropod-like" both in behavior and structure. The following is from Stimpson's report: "We are at once surprised by the activity it exhibits, and the high development of its organs. With its peculiar foot, when expanded, it can creep like a gasteropod, and when thus progressing, with its two long anterior cirri or tentacles waving in advance, it strongly recalls that higher order of mollusks. . . . The animal is everywhere white, nearly transparent. The mantle expands much beyond the margin of the shell, and is open in front, with undulated but unfringed margins. The anterior tentacles are two in number, simple and somewhat longer than the shell. A single posterior cirrus arises from the mantle on the dorsal surface, and is kept in continual motion like the anterior ones. The foot is a large, powerful organ, and may be expanded to a length equaling twice that of the shell." Stimpson's

account lacked figures but Dall (1899) later published Stimpson's sketches of the living animal. The literature does not show that this animal has been seen alive since Stimpson's observations.

According to Stimpson, *Lepton longipes* "generally occupies the holes of marine worms and fossorial crustacea." Since in England, *Lepton squamosum* lives commensally in the burrows of the mud shrimp *Upogebia stellata*, Norman (1891) reasoned that *L. longipes* is a commensal with *Upogebia affinis* and *Callianassa major*, but this has never been demonstrated. From our own observations, it appears that *L. longipes* definitely is not a commensal with *U. affinis*. The specific commensal relationships of *L. longipes* thus remain unknown.

On December 1, 1967, we discovered seven small bivalves attached to the upper wall of a burrow of *Squilla empusa*, which upon examination under a dissecting microscope, proved very similar in appearance and behavior to Stimpson's *L. longipes*. These and additional specimens collected subsequently from the same specific habitat are all smaller (ca. 2.3–3.0 mm.) in length than the half an inch (12.7 mm.) length given by Stimpson for *L. longipes*. That our specimens are not merely young *L. longipes* is indicated by the fact that all seven bivalves in the December 1 collection brooded young in the suprabranchial cavity. These individuals also differed from *L. longipes* in that the median posterior tentacle was much shorter than the two anterior ones, whereas Stimpson's figure showed these to be about the same length in *L. longipes*. The shells of our specimens when compared with those of Stimpson's of *L. longipes* in the United States National Museum were found to be quite similar in general appearance, although much smaller and more globose. It is concluded that these two forms are closely related but separate species.

The occurrence of "gastropod" bivalves, an interesting counterpart to the recently discovered "bivalve" gastropods, is a striking illustration of the evolutionary plasticity to be seen in the phylum Mollusca.

HETERODONT AFFINITIES OF THE LUCINACEA

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(Abstract)

The anatomical and conchological features of Lucinacean bivalves have been reviewed. The thesis advanced by McAlester, namely, that lucinoids form a lineage worthy of subclass rank, is refuted. The structure of the alimentary canal, the kidney system, the musculature, and the ctenidia as well as the ontogenetic occurrence of distinct anterior and posterior lateral teeth and of an opisthodetic, parivincular ligament are all characters which relate the Lucinacea to an assemblage of higher bivalves, frequently called Heterodonta, which include among others, the Carditacea, Crassatellacea and Veneracea. The Lucinacea assuredly date from the genus *Ilionia* of the Silurian Period and possible from one of the earliest bivalves, *Babinka* of Ordovician age. With this interpretation of lucinoids and their heterodont affinities, the

basic differentiation of the bivalve stock must have occurred in the early Paleozoic or Cambrian.

AN IMMUNOLOGICAL APPROACH TO LYMNAEID SYSTEMATICS[1]

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(Abstract)

Systematics of the world-wide freshwater pulmonate snail family Lymnaeidae have been the subject of very divergent views (e.g., see Baker, 1911, *Chicago Acad. Sci., Spec. Publ.* **3**, 539 pp.; Baker, 1928, *Wisc. geol. natr. Hist. Surv.*, **70** (1): 1–507; Hubendick, 1951, *Kungl. Svenska Vetensk.-akad. Handl.*, ser. 4, **3**(1): 1–223; Zilch, 1959–60, *Handb. Paläzool.*, Borntraeger, Berlin, pt. **2**, 834 pp.; Taylor, Walter & Burch, 1963, *Malacologia*, **1**(2): 237–281). Since the existing confusion results mainly from a serious lack of critical comparative biological information on the group, there is little wonder that there are continuing disagreements as to what constitutes a species, the number of species, how to regard the species-group, etc. Our immunological studies are intended to help elucidate biological and systematic relationships in this wide-spread, often studied, yet poorly understood family.

Our previous results with the planorbid genus *Bulinus* using the Ouchterlony gel double diffusion technique showed that there was immunological correspondence in foot muscle proteins among species of a particular species group, and an immunological dissimilarity between species of two different but related species groups (cf. Burch, 1967, *Papua & N. Guinea sci. Soc. ann. Rept. & Proc.*, **18**: 29–36). Therefore, this method would seem to be potentially valuable in other basommatophoran taxa to show species-group relationships of species of doubtful taxonomic placement. Preliminary studies with the Lymnaeidae indicate that the species groups *Lymnaea, Bulimnea, Fossaria, Pseudosuccinea, Radix* and *Stagnicola* are each immunologically distinct. Further, by immunological criteria, *"Lymnaea" volutata* does not belong to the *Bakerilymnaea* (= *Nasonia*) species group as recently supposed, nor does it belong to the *Radix* (as represented by *R. auricularia, R. japonica*, and *R. natalensis*) or *Fossaria* species groups. Future studies should determine whether or not the *viridis-ollula-volutata* series belongs to their own species-group complex, and whether or not they are related to or should be included with *"Austropeplea" tomentosa* and *"Peplimnea" lessoni*, as their chromosome numbers would indicate.

Of special significance to us is an elucidation of the relationships of those species of the Pacific area which have only 16 pairs of chromosomes (Burch, et al., 1964, *Malacologia*, **1**(3): 403–415; Inaba, *pers. comm.*), since these are the lowest numbers known in the Lymnaeidae. Most Lymnaeidae have 18 pairs of chromosomes, but *Radix* (from Japan, Formosa, India, Africa, Madagascar, Turkey, Italy and France) is characterized by only 17 pairs of chromo-

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somes (Burch, 1967, *Venus, Jap. J. Malacol.*, **25**(3–4): 118–135). Burch (1965, *Proc. 1st Europ. malacol. Congr.*, London, pp. 215–241) correlated increase in chromosome number with increase in specialization or phylogenetic advancement among euthyneuran snails in general, and in regard to the Lymnaeidae, speculated that the original lymnaeid ancestors had less than 18 pairs of chromosomes. Kondo (cf. Burch, 1967, *Venus, Jap. J. Malacol.*, **25**(3–4): 122) suggested that such a species as "*Lymnaea*" *ollula* (n = 16) may have entered the Pacific area during the late Paleozoic or early Mesozoic, and given rise to various of the current Pacific species. Patterson (1968, *J. Mar. biol. Assoc. India*, in press) presented the suggestion that such species as "*L.*" *ollula*, "*Austropeplea*" *tomentosa* and "*Peplimnea*" *lessoni* are perhaps the primitive lymnaeids which gave rise to *Radix*, which in turn gave rise to the other lymnaeids.

In regard to the wide differences of opinion concerning the number of lymnaeid genera, we share the opinion of Taylor, Walter & Burch (1963, *Malacologia*, **1**(2): 239) that the taxonomic procedure of including all species in the one genus *Lymnaea* obscures more than it reveals. To us, a genus is an artificial man-made category of convenience used to group those reproductively isolated populations which in some fashion or another are more similar to each other than they are to other assemblages of reproductively isolated populations. Whether or not these categories are defined morphologically, cytologically, biochemically, physiologically, reproductively, ecologically, or otherwise, is of little consequence as long as we can define the parameters of the particular characters being used to distinguish the biological entities under consideration. Whether or not these biological entities can be defined now by discontinuous morphological types is also of little importance to us. What we are interested in is the demonstrable relationship or lack of relationship between biological entities, whether these entities are individuals, populations, groups of populations, races, species, or groups of species, and how these categories may be grouped together by similarities, what we can infer about the significance of their dissimilarities, and how these entities are distributed geographically. We do not believe that a morphological study alone will give us these answers for the Lymnaeidae.

Editor's Note. Dr. John B. Burch was unavoidably prevented from attending the meeting in Corpus Christi and his paper was read there by title only. However, this paper, which we present here, proved to be of such importance to the study of lymnaeids that the editor submitted it to Dr. Harold J. Walter for his comments. These comments together with Dr. Burch's response hence appear together in the following pages.

COMMENTS ON THE PAPER BY J. BURCH AND G. LINDSAY

Harold J. Walter

I doubt that any bioscientist denies that genera are artificial, in one sense, or that a "morphological study alone" is preferable to a multifaceted approach to biosystematics. I hope that everyone recognizes the possible potential

value of immunological data when integrated with other information, especially morphological.

It is most important that the great need for furthering lymnaeid morphology knowledge not be denigrated. Research in this area ought to be promoted as vigorously as possible. It is neglect and misuse of this approach which have instigated the confused, misdirected views that have prevailed until now, and some important misunderstandings that plague us yet. Lymnaeids are not "all that bad"; they have been made to appear so because of the generally unsatisfactory morphological work done on them, as my research has made all too clear. I have identified a considerable number of important morphological errors in the literature that can lead to misunderstandings in this discussion but which I have yet to discuss in publication.

It is important that authors care on what criteria taxonomic entities are defined. Is it possible for one not to mind if such entities can be defined now and still insist on recognizing them by formal taxonomic names, before they can be defined? Surely, immunological and chromosomal data are relatively useless except in a context of detailed, accurate morphological data. On preliminary immunological data Burch and Lindsay state that the morphologically poorly known *Lymnaea "volutata"* does not belong to *Radix* and imply that the same may hold for *L. "ollula"* (I suspect that the one ought to be considered a geographic race of the other). I have found, on detailed study, that *L. "ollula"* (graciously provided me by Dr. Burch), is a "full *Radix,*" not clearly separable anatomically from the more typical Eurasian radicines. The immunological findings then, strengthen my contention that genera simply "don't work" for lymnaeids.

We cannot recognize various lymnaeid genera and adhere to a reasonably natural classification because of peculiarities of the evolutionary biogenetics of the family, amply demonstrated by knowledge now on record. If we recognize *Radix,* we must place in it anatomical radicines having a *"Stagnicola palustris"* shell and bicuspid lateral teeth (in large or small part), including *"S. turricola"* (see Jackiewics, 1959, Pub. Sec. Biol., Dept. Math. Nat. Sci., Poznan Soc. Friends Sci., **3**: 19) and *L. "palustris"* (see Hubendick, 1951, Kungl. Sven. Vet.-akad. Handl., ser. 4, **3**: 1, fig. 203, p. 85). We also would have to include species with a *"Fossaria"* shell and 16 pairs of chromosomes, such as *L. "ollula."* It should be noted here too, that *"Omia onychia"* (a race of *"R." auricularia*?) has bicuspid lateral teeth, although otherwise it is fully radicine. It is also important to point out that the radicine prostate is very distinctive morphologically, and that I have found the size of nuclear whorls to have no correlation with supposed generic characters in lymnaeids.

If we recognize *Stagnicola,* we must include *"S. corvus,"* which (see Jackiewics, op. cit.) has an *"S. palustris"* shell, in the same genus with *L. stagnalis* because these species, except for details of penial structure, have the same anatomy. We then would have to relegate to separate genera, on major anatomical disparities, North American *"Stagnicola," "S."-sp.* from England (see my paper in this bulletin), *L. atkaensis,* and *L. luteola,* and once embarked on this course, we would be forced to add other genera, perhaps many, to this systematic hodge-podge. Abundant refined data force me to admit that *L. catascopium* is much more closely related to *"Lanx"* than to *"S. corvus,"* and much less to *"Radix."* Therefore, recognition of such genera has obscured more than it has revealed about the most fundamental probable rela-

tionships among lymnaeids. Likewise, recognition of the 55 or so American "species," which probably all are variants of *L. catascopium*, obscures more than it reveals about the biogenetic nature of this constellation of forms, and also discourages research on their biology. I think that if malacologists wish to rank among zoologists who recognize the now aging "New Systematics" and the biological polymorphic species, they must give up insisting that everything they can "recognize" is a species or taxon.

My views on these matters were derived from a biomorphological approach in which I carried on extensive field and laboratory investigations (in the New and Old Worlds) of lymnaeid population dynamics, ecology, behavior, physiology (in a restricted sense), etc., while conducting intensive, long-term morphological studies. I was a party (Taylor, Walter, and Burch, 1963, Malacologica, **1**: 2) to the statement that lumping all lymnaeids in *Lymnaea* had disadvantages, but then so does our Linnaean system. I have faced up to specific facts which do not permit me to accept formal categories which some colleagues expect me to cling to. I hope it is clearly understood that I am in no sense "lumping" as Hubendick (op. cit.) has done for want of adequate data on basic lymnaeid anatomy.

MORPHOLOGY VS. IMMUNOLOGY. RESPONSE BY J. B. BURCH

Dr. Walter has misinterpreted the intent of our research. We do not envision a conflict with anatomical studies, nor have we implied this; in fact, our whole research effort is directed toward supplementing morphological data, especially in those groups where it is difficult to make systematic assessments because of lack of obvious gross morphological characters, or because of the difficulty in determining the significance of observable morphological variation. One of the reasons we are interested in conducting immunological studies on Lymnaeidae is that certain taxa have been notoriously difficult to classify, and taxonomic and zoogeographical relationships of many species are obscure. The problems Dr. Walter mentions, in which certain shell types do not correspond to anatomical groupings, indicates to me that most likely convergence or parallel evolution in one or more characters has occurred. The immunological techniques we are using are ideal for determining which characters are the result of convergence, and which are due to close phyletic relationship. The problems that Dr. Walter mentions also indicate that the present nomenclatural system based on shell characters may have to be changed significantly. But the current problems, due to nomenclatural confusion resulting from past inadequate knowledge, do not necessarily indicate that valid recognizable species groups do *not* occur within the Lymnaeidae. We are quite aware of the need for a more adequate taxonomic and nomenclatural system for this family, and it is precisely for this reason that we initiated our research.

I see no objection to placing species with "*Stagnicola palustris*-like" shells in either or both of the radicine and *Lymnaea stagnalis* anatomical groups. Neither do I see any objection to naming additional species groups, should the need arise. And simply because, in the past, species have been assigned to generic groups on the basis of superficial characters does not negate the actual occurrence of valid species groups in the Lymnaeidae. Dr. Walter's objections to recognizing species groups in this family seem to be based more

on current nomenclatural confusion rather than on lack of morphologically definable groups.

A good example of convergence of certain shell characters is demonstrated between the lotic lymnaeid species in Hawaii and Japan. "Lymnaea" ("*Omia*") *onychia* (Lake Biwa) and "*L.*" ("*Erinna*") *newcombi* (Kauai I.) have shells which display a strong ancyliform or nearly limpet-like tendency. An additional species occurs in each of these geographic areas which seems to represent an intermediate stage in progressive shell reduction: "*Radix*" *hamadai* (Kyushu I.) and "*Lymnaea*" *aulacospira* (various Hawaiian Is.). Itagaki (1959, *Venus, Jap. J. Malacol.*, **20**(3): 274–284) has previously shown "*Lymnaea*" *onychia* to be radicine in anatomical characters and Habe (1968, *Venus, Jap. J. Malacol.*, **26** (3/4): 78–79) considers *hamadai* to be very closely related to *onychia*. Incidentally, both of these Japanese species have the 17 pairs of chromosomes which, in the Lymnaeidae, are found only in the *Radix* species group ("*Lymnaea aulacospira*" has 18 pairs of chromosomes, characteristic of most non-radicine lymnaeids, and we would assume that this species is not radicine in anatomy). Undoubtedly, similar cases of convergence in shell or other characters will be found in the Lymnaeidae, and quite possibly they will occur in various species with "*Stagnicola palustris*" shells. And such convergence *per se* need not render a nomenclatural system based on species groups untenable.

We have used the cautious terms "preliminary" and "potentially valuable" simply because we consider our work at its current stage to be preliminary, since it does not yet represent most of the extant species in each of the immunological groups. We of course realize that our technique is not only potentially valuable, but that it is indeed a very useful tool for showing systematic relationships, or lack of relationship, in the Lymnaeidae, as well as in other groups (e.g., Burch, 1968, *J. Mar. biol. Assoc. India*, (in press); Davis, 1968, *Ibid.*, (in press)). We have demonstrated to our satisfaction that "*Lymnaea volutata*" (perhaps only a local variant of "*L. ollula*," as also mentioned to me on several occasions by Dr. Yoshio Kondo; incidentally, the two species are antigentically identical in regard to their foot muscle proteins and both have 16 pairs of chromosomes) is antigentically different from *Radix auricularia, R. japonica* and *R. natalensis*. The latter three species are all antigentically similar, but each is different from all other lymnaeids tested. "*L. volutata*" is likewise antigentically different from all other lymnaeids tested, except for "*L. ollula*." We have observed similar groupings with other lymnaeids. Therefore, we are led to the conclusion that species groups do indeed exist in the Lymnaeidae. Because of similarities in certain morphological characters, some workers may wish to regard each "group of species" as actually only one species. Such a practice might then eliminate the need to recognize species groups. However, I wish to inject a word of caution in this regard for the following reasons: 1) Neither reproductive isolation nor ability to interbreed has been demonstrated for any of these lymnaeid populations, so it is difficult to assess accurately what morphological variation might be ascribed to a lymnaeid species; 2) An example may be taken from the planorbid subgenus *Bulinus* s.s. to show the great difficulty snail morphologists have had in distinguishing certain reproductively isolated populations (i.e., species) of freshwater pulmonate snails (cf. Burch, 1967, *Malacologia*, **5**(2): 127–135) (similar cases of morphologically nearly identical sibling species

may well occur in several different groups of the Lymnaeidae, although their method of reproductive isolation may be different from that in *Bulinus*); 3) "*Fossaria rustica*" appears to be quite similar to other "species" of *Fossaria,* such as *F. obrussa,* and has been considered synonymous with the other nominal species of this group in North America (Hubendick, 1951, *Kungl. Svenska Vetensk.-akad. Handl.*, ser. 4, **3**(1): 1–223, considers nearly all North American *Fossaria,* including *F. rustica* and *F. obrussa,* to be synonymous with "*Lymnaea humilis*"). Nevertheless, "*F. rustica*" (n = 19) appears to be cytologically distinct from other *Fossaria* species (n = 18), by possessing two additional chromosomes (populations have been studied from Ohio, Michigan and Idaho; cf. Burch, 1960, *Nucleus,* **3**: 177–208; Inaba, 1969, *Malacologia,* [in press]).

We agree with Dr. Walter that taxonomists should care about the criteria on which taxa are defined. Otherwise they may not appreciate the fact that different taxa actually do exist, and that such taxa may be defined by a number of different characters (which may not be mutually inclusive), e.g., morphological, cytological, biochemical, physiological, reproductive, ecological, behavioral, etc., characters. We can test the immunological correspondence, or lack of it, between individuals of any two taxonomic entities given us, separated on any one or more characters one wishes to use, and we will provide taxonomically useful information. And we can provide this information regardless of the completeness of currently defined morphological parameters. In fact, we envision that in some cases such an immunological study might actually be decisive in initially determining the actual morphological parameters of various taxa. [Chromosome cytology proved to be such a tool in separating individuals for the later unravelling of the seemingly overlapping morphological parameters of various *Semisulcospira* species of Lake Biwa (cf. Burch & Davis, 1967, *Amer. malacol. Union Ann. Reps.*, **34**: 36–38; Burch, 1968, *J. Conchyl.*, **107**: (in press); Davis, 1969, *Malacologia,* **7** (in press))]. We do not mean to imply that in practice we ignore morphology. Indeed, careful records and specimens for morphological study and museum deposit are kept of all our material (some of it has already gone to Dr. Walter for his study), and when our immunological data are complete, we expect to correlate the results with anatomical information.

We are greatly interested in all types of recognizable systematic entities within the Lymnaeidae, whether they be individuals, populations, groups of populations, races, species, or groups of species, and we feel that much is yet to be learned about all of them. Additionally, we feel that all malacologists should be perceptive enough to recognize and appreciate differences and similarities at various levels of taxonomy, and we certainly do not believe that any animal that can be recognized as being morphologically different from another is *a priori* a "species," or a taxonomic category that should receive a formal name (cf. Burch & Thompson, 1957, *Syst. Zool.*, **7**(1): 48).

Because of our own researches on the Lymnaeidae (which include some morphology), we are anxious to see Dr. Walter's lymnaeid studies published in greater detail, and we wish to assure him that in no way do we intend to "denigrate" morphological research, but conversely, we are fervent supporters of this aspect of science, especially as it relates to systematics. Additionally, we fully expect immunology to supplement morphology, not to supplant it or

to compete with it, and that the two approaches, along with cytology and other disciplines, will soon place lymnaeid systematics on a more tenable footing.

LARVAL DEVELOPMENT OF THE COMMENSAL BIVALVE, *MONTACUTA PERCOMPRESSA*

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AND

MATOIRA CHANLEY

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(SUMMARY)

Montacuta percompressa is a small Erycinacean clam that attains a maximum length of about 5 mm. The female lives commensally with the holothurian *Leptosynapta inhaerens.* The male, less than 500μ in length, lives as a true parasite in the mantle of the female.

The female broods fertilized eggs in a brood pouch which is a modified posterior extension of the mantle. Although the extent of the breeding season is not known, brooding females were taken from North Carolina waters in September and from late February through April. After 5 to 7 days 450 to 16,900 larvae were released as straight hinge veligers 120 to 150μ long. Eggs did not develop normally if released from the brood pouch prematurely.

Larvae had an unusually long hinge line, 87 to 101μ, that did not change appreciably in length with larval growth. Length exceeded height by 30 to 35μ in early straight-hinge stages, and by 20 to 25μ when larvae were 150 to 350μ long. At metamorphosis length was 350 to 385μ and exceeded height by 25 to 30μ. *M. percompressa* larvae were much more laterally compressed than most bivalve larvae. During development depth increased from 40 to 175μ, and was from 80 to 200μ less than length.

A low round inconspicuous umbo began appearing at about 200μ and obscured the hinge line when larvae were about 250μ long. The umbo eventually became broadly rounded but remained low. Umbo and shoulders made up only about one-third the total height with the anterior shoulder longer and sloping more gradually than the posterior.

The anterior and posterior ends were of equal length and roundness until late umbo stages. As larvae approached metamorphosis, the anterior end became flattened and directed ventrally while the posterior end was shorter and more broadly rounded than the anterior. The ventral margin was almost semicircular, but became somewhat flattened in late larval stages. The velum was large and had a long conspicuous apical flagellum. Larvae were pale throughout development; however, the digestive diverticulae did assume a color from the food. A large rectangular ligament appeared internally in the anterior portion of the otherwise undifferentiated hinge when larvae were about 310μ in length.

Pediveligers and recently metamorphosed juveniles showed no recognizable behavioral response in the presence of either the host organism or adult females or both.

LITERARY MOLLUSKS

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New York Shell Club

(Abstract)

Poets, novelists, essayists, and philosophers have made frequent references to mollusks and their shells to construct similes and metaphors, to point a moral, and to reflect on the moods of nature. Through a series of quotations from American, British, Spanish, French, and German authors it was shown that the molluscan shell serves as a symbol of beauty, shelter, and protection. The animals are associated with slowness, stubbornness, lethargy as well as such unpleasant sensations as cold, damp, sliminess, and formlessness. The talk also included some quotations showing that mistaken notions of shells and mollusks are widespread and firmly fixed in the mythology of our race.

THE MARINE MOLLUSCAN FAUNA OF THE MARQUESAS ISLANDS

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The Marquesas Islands are an isolated group of high volcanic islands, ten in number, varying in area from 130 square miles (Nukuhiva) to half a square mile (Fatuhuku), and situated 700 miles northwest of Tahiti. The mountains of these islands rise to an elevation of 4,130 feet on Nukuhiva; even Fatuhuku's highest peak is 1,180 feet. Steep cliffs and deep bays characterize much of the coastline of these islands.

The closest islands to the Marquesas are the tiny atolls of the Tuamotus, 300 miles to the south, and the small atolls of Caroline, Flint, and Vostock, 600 miles to the west, while the nearest high islands are the Society Islands 700 miles to the southwest.

This isolation, and the fact that the Marquesas are without any fringing or barrier coral reefs have apparently led to a neglect of these islands by marine biologists and a consequent poor knowledge of their marine fauna. A compilation of the marine mollusks of French Polynesia published by Dautzenberg and Bouge in 1933 lists about 1,100 species and subspecies; of these only 93, or 8½%, are recorded as occurring in the Marquesas.

Through the cooperation of Mrs. Mariel King of Honolulu, the National Geographic Society, and the Bernice P. Bishop Museum I was able to spend three weeks in the Marquesas as leader of a group of scientists on board Mrs. King's research vessel "Pele."

On September 14, 1967, we arrived in Taiohae Bay, Nukuhiva, and spent the next six days dredging and doing shore collecting in and off some of the bays on the eastern part of the Nukuhiva. We next headed northward and let down two dredges off Motu Iti. Continuing in a northwesterly direction we made several dredge hauls off Eiao, another small island 57 miles northwest of Nukuhiva, and off the neighboring island Hatutu. We tried to land on Eiao but the sea was too rough and the landing precarious. Ten miles

northeast of Hatutu we came up to Ile de Sable which we found to be a low sand bank, without vegetation, situated on a rather extensive shoal. After examining it through our glasses and not wanting to risk a closer approach because of the shallow water and rough sea we turned about and headed back for Nukuhiva which we reached during the night. We made several dredge hauls off the northwest coast of Nukuhiva and then sailed for Uapou, 23 miles to the south.

After two and a half days on Uapou, dredging and doing shore collecting and diving on the west coast of the island, we left for Fatuhiva, the southernmost island in the Marquesas. On the morning of September 25, after a thirteen hour run, we were off the steep cliffs of the lushly verdant island of Fatuhiva, where we spent three days in collecting.

In the early morning of the 28th we steamed northwestward to Tahuata, where five days were spent collecting in the bays on the west and north coasts of Tahuata. We also dredged extensively in Bordelais Channel between Tahuata and Hivaoa. From here we returned on October 3 to Taiohae Bay, Nukuhiva.

In the twenty days spent in the Marquesas we not only gathered much material, but learned a great deal about the ecology and constitution of the marine molluscan fauna. We found that although there are no exposed coral reefs there are rich small reefs below the surface along the shores of the many bays of these islands, and also small patch reefs in these bays and off the coasts of the islands. Dredging proved very rewarding, and revealed an unsuspectedly rich fauna at depths of 20 to 50 fathoms. The results of this trip, and of the efforts of a collector who spent several months in Taiohae Bay, have given me a good general picture of the fauna and allow me to make these observations.

First, the marine molluscan fauna of the Marquesas is much richer than I expected, containing a high percentage of widely distributed typical Indo-Pacific species. The following list covers only the most common mollusks and some of the more striking species:

Turbo setosus Gmelin	C
Nerita plicata L.	C
" *polita* L.	C
Nodilittorina pyramidalis Q. & G.	C
Heliacus variegata Gmelin	C
Philippia hybrida L.	C
Cerithium mutatum Sby.	C
Strombus dentatus L.	F
Cypraea helvola L.	C
" *mauritiana* L.	C
" *caputserpentis* L.	C
" *carneola* L.	M
" *tigris* L.	M
" *maculifera* Schilder	C
" *fimbriata* Gmelin	C
" *atomaria* Gmelin	F
" *beckii* Gaskoin	F
Cypraecassis rufa L.	F

Cymatium aquatile Reeve	M
" *pileare* L.	F
" *rubecula* L.	F
" *nicobaricum* Röd.	M
Bursa bufonia Gmelin	M
" *lampas* L.	F
" *cruentata* Sby.	F
" *granularis* Röd.	F
Chicoreus ramosus	M
Homalocantha anatomica Mawe	F
Morula cornus Röding	M
" *granulata* Duclos	C
" *uva* Röding	M
Drupa grossularia Röding	C
" *ricinus* L.	C
Maculotriton serriale Lab. & Desh.	M
Nassa sertum Brug.	F
Coralliophila violacea Kiener	M
Quoyula madreporarum Sby.	F
Pollia undosa L.	M
Pisania decapitata Reeve	M
Alectrion papillosus L.	M
Latirus nodatus Gmelin	C
Mitra ferruginea Lam.	F
Harpa amouretta Röding	M
Conus bullatus L.	F
" *catus* Hwass	C
" *imperialis* L.	C
" *quercinus* L.	C
" *rattus* Hwass	C
" *sponsalis* Hwass	C
" *textile* L.	M
" *vexillum* L.	F
Terebra maculata L.	M
Hydatina amplustre L.	M
Pinctada margaritifera L.	M
Streptopinna saccata L.	M
Gloripallium pallium L.	M
Periglypta reticulata L.	C
Lioconcha picta Lam.	C

C = common; M = moderately abundant; F = few (1 to 5 specimens)

Many of the species occur here in a dark form: *Nerita polita* is found only in the black form; *Harpa amouretta* and *Terebra maculata* are both dark-colored.

Secondly, some of the species have a rather restricted distribution that shows certain affinities with island groups to the north and northwest rather than with the Society Islands and the Tuamotus.

Purpura persica L., for instance, is found in the Indian Ocean, through Indonesia and the Philippines to the Ryukyus, Bonins, Wake Island, Marianas,

and Caroline Islands, and also in two isolated colonies in the Loyalty Islands and the Marquesas.

The two specimens of *Strombus dentatus* seen from the Marquesas are like the smooth form found in Hawaii, and not like the strongly ribbed form from the islands to the south and west.

A third fact worthy of note is the rather high degree of endemicity found in the fauna, as evidenced by the following list:

Chiton marquesanus Pilsbry
Nodilittorina cinerea Pease
Lambis crocata pilsbryi Abbott
Cypraea cassiaui Burgess
Chicoreus steeriae Reeve
" *thomasi* Crosse
Drupa iodostoma Lesson
Latirus fallax Kobelt
Peristernia lirata Pease
Cyrtulus serotinus Hinds
Conus vautieri Kiener
" *encaustus* Kiener
" *marchionatus* Hinds
Terebra crenulata new subsp.
" *trochlea* Deshayes

This list includes only those species we found and that we have identified; that there are others to be added, not only as yet unidentified but also undescribed new species is certain. Considering these facts it is very likely that the 20% degree of endimicity evidenced in these lists will remain as the fauna is worked up.

It is interesting to note that 55 of the 73 names listed here are not recorded by Dautzenberg and Bouge as occurring in the Marquesas.

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MOLLUSCA OF EL PASO COUNTY, WESTERNMOST TEXAS

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El Paso County is the westernmost county in Texas, located in the Basin and Range Physiographic Province and in the northern part of the Chihuahuan Desert. The climate is arid, with an average annual precipitation of *ca.* eight inches. The Hueco Mountains, reaching elevations of approximately 5,000 feet, border the county on the east, and the Franklin Mountains, reaching altitudes over 7,000 feet, are located in the western part of the county. Between the ranges is a sparsely vegetated intermontane basin, the Hueco Bolson. Bounding the county on the west and south and separating it from the Mexicos, Old and New, is the Rio Grande.

The Rio Grande itself is an inhospitable environment for aquatic mollusks in El Paso County, as the amount of water let into it from reservoirs upstream in New Mexico is related to the needs of irrigation. Parts of the river may be completely dry for months at a time. Likewise, irrigation canals fluctuate and are completely dry during the winter months. However, the pulmonate snail *Bakerilymnaea bulimoides techella* (Haldeman) manages to propagate itself in the canals despite the periodic desiccation. A more hospitable aquatic environment is provided by a system of drainage ditches constructed to drain off excess ground water. Some of these ditches flow permanently and contain populations of *B. b. techella*, a *Fossaria*, *Physa virgata* Gould, *Ferrissia fragilis* (Tryon), and the exotic clam *Corbicula manilensis* (Philippi). In some oxbow pools along the Rio Grande and in impoundments in the city of El Paso and at Hueco Tanks in the Hueco Mountains a *Planorbella* occurs.

There is little riparian forest along the Rio Grande in El Paso County except for some stands of salt cedar (*Tamarix*), which do not seem to harbor mollusks.

In lawns and parks in the city of El Paso, eight species of terrestrial gastropods were taken. Of these, four seem native to the area: *Gastrocopta cristata* (Pilsbry and Vanatta), *Helicodiscus singleyanus* (Pilsbry), *Hawaiia minuscula* (Binney), and *Deroceras laeve* (Müller). Four species seem to have been introduced: *Vallonia pulchella* (Müller), *Rumina decollata* (Linnaeus), *Lehmannia poirieri* (Mabille), and *Helix aspersa* Müller.

To date, only four species of terrestrial snails have been taken in the Hueco Mountains, but this range deserves further investigation.

Collections made at 33 localities in the Franklin Mountains between elevations of 4,000 and 7,000 feet have revealed 13 living species: *Gastrocopta ashmuni* (Sterki), *Gastrocopta pellucida hordeacella* (Pilsbry), *Vallonia perspectiva* Sterki, *Succinea*, sp., *Bulimulus pasonis* Pilsbry, *Holospira roemeri* (Pfeiffer), *Helicodiscus singleyanus* (Pilsbry), *Retinella indentata* (Say), *Hawaiia minuscula neomexicana* (Cockerell and Pilsbry), *Deroceras laeve* (Müller), *Ashmunella pasonis* (Drake), *Thysanophora horni* (Gabb), and *Sonorella* sp. *Pupoides albilabris* (C. B. Adams) occurs on piedmont slopes west of the mountains.

Pleistocene deposits containing both aquatic and terrestrial species occur in the Hueco Mountains and under the Picacho Surface bordering the Rio Grande Valley. Seventeen species of terrestrial snails have been found in Pleistocene deposits in canyons in the Franklin Mountains.

MOLLUSCAN NERVE CELLS: DISSOCIATION AND REAGGREGATION[1]

VERA KING FARRIS,[2] DAVID LEE WEILER, AND ROBERT RUBIN
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Early in 1967 Farris reported that the ovotestes of adult *Helix pomatia* could be dissociated in the presence of two carbohydrates, galactose and

[1] This investigation was supported by a research grant (AI 07364) from the National Institutes of Health, U. S. Public Health Service.
[2] Supported by Public Health Service Fellowship F2-AI-32, 179.

trehalose, in addition to trypsin. Further, the same experiments revealed that the cells, once separated, rapidly reaggregated into tissue histologically similar to the original organ. Since that time nearly all the major organs of *Helix* have been investigated, and have shown the same phenomenon. However, several difficulties were encountered with the disaggregation of the nervous system.

The nervous system of *Helix pomatia* is of the heliciform type and consists of the following ganglia together with the usual commissures: buccal, cerebral, pedal, pleural, parietal, and visceral. Giant cells occur in many of the ganglia, some as large as 400 microns in diameter. One oddity of the pulmonate central nervous system is the enclosure of the ganglia and proximal parts of the main nerves in a sheath of dense connective tissue.

Tissue was obtained from the buccal, pedal, and cerebral ganglia and associated commissures of adult specimens of *Helix pomatia*. Aseptic techniques were employed throughout the experiments. The results indicated that solutions for the disaggregation of nerve cells required an increase in pH (8.0 to 8.2) and heat (35°C.) in addition to the two carbohydrates plus trypsin. Under these conditions all the cells normally found in the nervous system were released intact and were viable. The necessity for the presence of heat and the increase in pH is due probably to the ensheathment of the nerves in the dense connective tissue.

The cells obtained during dissociation possess several properties of a nature previously unreported for differentiated molluscan nerve cells. One type of cell, uncharacterized as yet, which is normally elongate in the tissue, undergoes many active contractions when separated from the tissue, then rounds up into a spherical cell and produces active pseudopodia. All the other types of cells are capable of producing one to many pseudopodia also.

The same experiments demonstrated that the dissociated cells, when centrifuged, reaggregate into histotypically organized tissue within 30 minutes. (Time lapse movie of reaggregating nerve cells.)

MOLLUSKS OF PROJECT HOURGLASS

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In August 1965, the Florida Board of Conservation Marine Laboratory began a 28-month benthic sampling program in the eastern Gulf of Mexico. Because of the configuration of the cruise pattern the program was named PROJECT HOURGLASS. Five stations were selected at 20 feet, 10, 20, 30, and 40 fathoms due west of St. Petersburg, and five analogous stations were selected due west of Sanibel Island. These established stations were sampled each month with dredge, trawl, and plankton net. Samples were returned to the laboratory for sorting and analysis.

Collecting is now completed and sorting of the material is nearly finished. RATIONALE AND PERTINENT DATA, Volume 1, Part 1, is now in manuscript form, as are reports on the algae and marine diatoms. Papers are now in preparation for the fishes and many of the invertebrate groups.

The first molluscan report from the HOURGLASS cruises will present identifications, observed ecological data, and known zoogeographic ranges for the animals collected with dredge and trawl. Approximately 900 species representing 150 families have been found to date. An analysis of ecological data and known distributions will be undertaken to determine, where possible, the factors that are most influential in the formation of these molluscan assemblages.

Mollusks from the plankton will not be dealt with in this report. They will be analyzed in a subsequent paper.

Representatives of all HOURGLASS species are being accessioned into the Florida Board of Conservation marine invertebrate reference collection at St. Petersburg, Florida. These specimens are available for study by qualified researchers upon request.

NOTES ON CAPTIVE *CERITHIUM VARIABILE* C. B. ADAMS AND *MITRA FLORIDANA* DALL

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(SUMMARY)

Cerithium variabile, described by C. B. Adams in 1845, is a very common intertidal species found in South Florida, Texas and the West Indies. In the Florida Keys it is most often found living in rocky areas with its look-alike, *Batillaria minima* Gmelin, in such numbers that they are easily collected by the handful. Originally collected as a food supply for *Mitra floridana* and *Leucozonia nassa* Gmelin, specimens of *Cerithium variabile* of 16 to 18 mm began to deposit egg clusters and so were kept for observation.

The egg capsules were contained within a gelatinous string which was extruded through a funnel-like groove formed by a contortion of the right side of the female's foot. Some of the strings were more or less stacked, appearing as loosely packed balls of mucus, others were stuffed into depressions in rocks. Still others were deposited over flat surfaces in slightly overlapping rows to form an unbroken sheet. Viewed laterally, the spheres of the egg capsules seemed to float above the base, attached by only the smallest of stems. Each capsule, judged to be about ⅓ mm in diameter, contained one minute, ivory-white egg.

The veliger stage is passed within the capsule. As hatching approaches the material of the capsules starts to disintegrate, and fully formed snails crawl away from the clusters after incubation periods of from 11½ to 14 days. The tiny round shells of the newly hatched are completely smooth and may be either the palest of tan or a rich brown. The operculum is round, corneous, and very thin. After five weeks, in specimens with two whorls of new, sculptured growth but still less than 1 mm in height, there were thin new extensions on the edges of the operculum toward the tear-drop shape. At 12 ± weeks in specimens of 1.3 mm the operculum had attained its characteristic shape.

Seven specimens, the survivors of one egg cluster, were raised to adulthood. They were kept in a container with no other species and fed on local algae.

Hatched the latter part of April 1967, their first of a number of fertile egg clusters was deposited on May 8, 1968. At 13 months they measured from 8½ to 11 mm in height and, though of similar coloring, their patterns vary.

Mitra floridana Dall, 1883, is quite a small species, adult at 6 mm. Those observed were collected from the underside of rocks, intertidal zone, on the Florida Bay side of Crawl Key, Florida, and now range from 6 to 8 mm in height.

The animal of *Mitra floridana* is all white except for the black eyes at the base of the tentacles; there is no operculum. It takes the female about an hour to deposit an egg case, which usually contains two eggs. It is extruded through the pedal vent which appears as a slit running anteriorly to posteriorly at the center of the foot. The sturdy case is a simple blister, irregularly oval to oval, 1½ to 2^+ mm in overall length including a narrow, flat rim, and is firmly attached to the substrate. The elliptical "hatch area" is situated slightly off-center in the dome of the case. The embryos pass through the veliger stage within the case and emerge fully formed and crawling after an incubation period which is most commonly around 23 days.

The shells of the newly hatched are about $.7^+$ mm in height and to .3 wide; they are a clear, dark red-brown in color and consist of a sharply reflected nucleus and one post-nuclear whorl, both without surface sculpture. The first sculptured growth was noted at 4 days; a complete whorl was attained as early as 6 weeks.

The *Mitra floridana* fed on *Cerithium variabile* and other small gastropods, immobilizing their prey, apparently with a "sting," before moving in to feed. Of victims withdrawn from the aquarium immediately after they had been attacked by adult *Mitra*: a 2 mm *Prunum apicinum* appeared to have died instantly and remained fully extended; a 9 mm *Planaxis lineatus* was dead in from 60 to 90 seconds; a 16 mm *Cerithium variabile* died in approximately 8 minutes; a 13 mm *Batillaria minima*, "stung" on the thick part of its foot, was dead in 24 minutes. Other specimens of *Batillaria* died much more quickly. Still others of these species, reacting instantly to brief contact by the mitra's highly extensible and mobile proboscis, made quick escape and were apparently unharmed.

Newly hatched *Mitra floridana* were not observed to feed until they were about 2 weeks old, then attacked and fed on newly hatched *Cerithium variabile*. At 4 and 5 weeks they readily attacked juveniles of *Lacuna vincta* and *Littorina saxatilis* that were about four times their size.

In the original description William Healy Dall listed this species as "*Mitra* (*Mitromorpha*?) *floridana*" and in his following remarks said, "This pretty little shell resembles a *Mitra*, but also recalls the forms named *Mitromorpha*, by Carpenter, which seem to stand conchologically between the cones and mitras." Dr. Dall described a dead shell. Observation of the feeding methods would seem to strengthen his speculation that this mollusk might indeed belong in another category. In the hope of further enlightenment, alcohol specimens have been donated for study of the radula.

The writer is indebted to Arthur S. Merrill, William E. Old and William K. Emerson for their help in the research, and to Anthony D'Attilio and George Raeihle for the illustrations.

NOTES ON PERIPLOMATIDAE (PELECYPODA: ANOMALODESMATA), WITH A GEOGRAPHICAL CHECKLIST

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(SUMMARY)

The Periplomatidae is a small family of the Subclass Anomalodesmata, Superfamily Pandoracea (Newell, 1965). It is related to the Laternulidae and sometimes considered part of that family. The two are generally easily distinguished on the basis of both shell and animal characters, by geographic distribution of Recent species, and by comparison of their fossil records. Laternulidae, according to Dall (in Zittel, 1900) are found in deposits dating from Jurassic to Recent whereas Periplomatidae date only from the Tertiary. Laternulidae exhibit nearly equivalve shells which gape posteriorly; their siphons are united and moderately long with a prominent horny epidermis. Periplomatidae are distinctly inequivalve and their valves are closable. Siphons are separate and naked. Both families display a unique feature among the bivalves, an umbonal crack, and the valves are buttressed internally in one way or another. A lithodesma is often present. Laternulidae are restricted geographically to the Indo-Pacific faunal region with few exceptions. A single "giant" species occurs in Antarctica and one species occasionally may reach our west coast by way of the Japan current. Periplomatidae occur on east and west coasts of tropical America, in the North Pacific, North Atlantic, in Europe, off both coasts of Africa, and one or two unusually large species occur in the tropical western Pacific.

Available data on habitat indicate that both Periplomatidae and Laternulidae live infaunally, buried in sandy to muddy sediment from near the low water mark to as much as 800 fathoms in depth. According to Clarke (1962) they occasionally may occur in depths of over 1000 fathoms. Most records indicate they are somewhat rare alive intertidally, but live commonly in only moderate depths below the tide line.

There follows an outline of the Periplomatidae wherein are reflected some of my views concerning the classification of the family. The species list probably is not exhaustive, but includes most well known forms.

Family Periplomatidae Dall, 1895

Periploma Schumacher, 1817; type-species by monotypy: *Periploma inequivalvis* Schumacher, 1817 [= *P. margaritaceum* (Lamarck, 1801)].

Western Atlantic

Periploma margaritaceum (Lamarck, 1801).
Periploma ovatum Orbigny, 1846.

Eastern Pacific

Periploma planiusculum Sowerby, 1834.

Albimanus Pilsbry and Olsson, 1935; type-species by original designation: *Periploma* (*Albimanus*) *pentadactylus* Pilsbry and Olsson, 1935.

Eastern Pacific

?*Albimanus pentadactylus* (Pilsbry and Olsson, 1935).

Halistrepta Dall, 1904; type-species by original designation: *Periploma* (*Halistrepta*) *sulcata* Dall, 1904.

Eastern Pacific

Halistrepta sulcatum (Dall, 1904).
Halistrepta myrae (Rogers, 1962).

[Group of "discoidal" *Periploma*]

Eastern Pacific

Periploma lenticulare Sowerby, 1834.
Periploma altum (C. B. Adams, 1852).
Periploma discus Stearns, 1890 (also reported from Dakar, Senegal, and *P. fractura* Boshoff, 1968 was dredged off Durban, South Africa in 1964).
Periploma stearnsi Dall, 1896.
Periploma carpenteri Dall, 1896.
Periploma teevani Hertlein and Strong, 1946.
Periploma largartilla Olsson, 1961.

Western Atlantic

Periploma orbiculare Guppy, 1882.
Periploma compressum Orbigny, 1846.

Offadesma Iredale, 1930; type-species by original designation: *Periploma angasi* Crosse and Fischer, 1864 [? = *Pendaloma* Iredale, 1930; type-species O.D.: *Periploma micans* Hedley, 1901].

Western Pacific

Offadesma angasi (Crosse and Fischer, 1864).
Offadesma nakamigawai Kuroda and Horikosi, 1952.

[Group of "northern" *Periploma*]

Western Pacific

?*Periploma ovatum* Kuroda and Horikosi, 1952 [not Orbigny, 1846].

North Pacific

Periploma alaskana Williams, 1940.

Western Atlantic

Periploma fragile (Totten, 1835).
Periploma abyssorum Verrill *in* Bush, 1893.

Cochlodesma Couthouy, 1839; type-species by monotypy: *Cochlodesma leanum* (Conrad, 1831) [= *Aperiploma* Habe, 1952, with the same type-species, O.D.].

Western Atlantic

Cochlodesma leanum (Conrad, 1831).

/

Western Pacific

Cochlodesma otohimae (Habe, 1952).

Galaxura Leach, 1852; type-species by monotypy: *Galaxura praetenue* (Pulteney, 1799).

Eastern Atlantic

Galaxura praetenue (Pulteney, 1799).
Galaxura tenerae (Fischer, 1882).

Western Atlantic

Galaxura undulatae (Verrill, 1885).
Galaxura affine (Verrill and Bush, 1898).

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OBSERVATIONS ON THE CAECIDAE

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The Caecidae, in contrast to many gastropod families, is made up of a very distinct, homogeneous group of species. The same plan of growth is followed by all in the family: as growth continues, the protoconch is shed, then an intermediate section. The adult shell is a curved tube closed at the posterior end by a septum.

It is at the generic and specific level that most difficulty is encountered. Some species have considerable variation, and this, combined with the three stages of growth and differences due to wear, has brought on a great deal of confusion. Much uncertainty is largely the fault of P. P. Carpenter, who published two major works, The Mazatlan Catalogue and the Monograph of the Caecidae, without a single illustration. The next major worker on the Caecidae was the Marquis de Folin, who figured all his species. Inability to understand variation in a species resulted in some being named several times from the same small bottom sample. The varying quality of his figures also compounded the confusion. Many workers since have ignored this previous work, and have described anew the species that they have studied.

Apparently all of the Caecidae have a pelagic larval stage. It may be much reduced, however, in species confined to an island group such as Puerto Rico and the Virgin Islands or a single island like St. Helena. Delimiting the geographical and ecological distribution of species is proving helpful in determining the amount of variation in closely related species.

Photomicrographs made with the Electron Scanning Microscope are also very helpful. These pictures show that many *Caecum* have longitudinal microsculpture. This sculpture does not seem to be of help on the generic level, but it appears to be very useful for separating species.

A PROGRESS REPORT ON A REVISION OF THE CUBAN HELICINIDAE (MOLLUSCA: PROSOBRANCHIA: ARCHAEOGASTROPODA)[1]

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(SUMMARY)

The revision of the Cuban helicinids, which was undertaken about two years ago, has been progressing steadily. The study of the genus *Viana* is now published, the studies of *Priotrochatella* and *Emoda* are nearing completion, and the paper on "*Eutrochatella*" is well advanced. This leaves the genera *Helicina, Alcadia, Proserpina,* and *Lucidella* (the last two containing only 3 Cuban taxa) to be completed.

Our treatment has been conservative and few new taxa are being introduced. On the other hand, however, we noted that many taxa which had been published especially in the Cuban "*Eutrochatella*," were not justified. Our procedure was to localize populations of these shells on an enlarged map of Cuba. We soon observed that we were dealing with polymorphic groups whose random distribution did not warrant specific or subspecific recognition. Hence we had to consider many well-known names as synonyms of other forms. In addition, we were able to declare invalid several manuscript names used by Carlos de la Torre for shells which he had distributed widely to museums and collectors.

A particularly interesting case was that of *hians* Poey 1852 which was overlooked in favor of *petrosa* "Gundlach" Pfeiffer 1857. Poey clearly stated that his *hians* had "perístoma simple, cortante," (Memorias Hist. Nat. Isla Cuba, **1**: 114). Yet in his Latin redescription of the taxon (1854, Malak. Blätter, **1**: 101) Pfeiffer wrote, "perist. expansum." Hence Pfeiffer's name and not Poey's was attached for years to the species with the simple, unexpanded lip. Poey's taxon was lost sight of; Sowerby (1866, Thes. Conchyl., **3**: 296) was unable to identify *hians* and it was completely omitted by Reeve (1874) and Wagner (1908). As a result we have restored *hians* in place of *petrosa* and have added several synonyms on zoogeographical grounds.

In our superspecific arrangement of the Cuban "*Eutrochatella*" we have leaned heavily upon the work of H. B. Baker (1922, 1926, 1928, 1956) but treat several of his subgenera as genera and his "sections" as subgenera. Sections have been eliminated from the taxonomic hierarchy (Art. 42d of the Code, 1962), but the distinctions noted by Baker deserve superspecific recognition. We justify our elevating of Baker's taxa by pointing to important radular distinctions associated with shell characteristics and zoogeographical considerations. Hence we recognize the following superspecific taxa to replace the "*Eutrochatella*" of Cuba: genus *Troschelviana* H. B. Baker 1922; subgenus *Troschelviana* s.s.; subgenus *Cubaviana* H. B. Baker 1922; subgenus *Microviana* H. B. Baker 1928; genus *Ustronia* Wagner

[1] Supported by NSF grant GB 1004.

1908: genus *Calidviana* Baker 1954 (synonyms: *Callida* Wagner 1908, not Agassiz 1846; *Bakerviana* Aguayo and Jaume 1957).

The subfamilial placement of *Eutrochatella* Fischer 1885 and allied forms has been varied. Baker (1922) set up the subfamily Vianinae in which he included the genus *Eutrochatella*. In 1928 he set up the subfamily *Stoastominae* based on *Stoastoma* C. B. Adams 1849 for the genera *Stoastoma* and *Stoastomops* H. B. Baker 1928. In 1956 he reduced the Vianinae to a tribe of Proserpininae and emended Stoastomidae to Stoastomatidae. Keen (1960) published Stoastomatinae, based on Baker's emendation, and expanded the limits to include all the groups which Baker had placed in his original Vianinae, including *Eutrochatella*.

It seems unwarranted to place *Viana* and *Eutrochatella* in a subfamily named for *Stoastoma*, a most untypical genus of tiny helicinids practically confined to Jamaica. Similarly, including them in the Proserpininae with the genus *Proserpina*, a strongly aberrant group of helicinids (no operculum, aperture with parallel lamellae, expanded mantle covering entire shell) is also unjustified. Hence we propose to separate the Vianinae from the Proserpininae and Stoastominae and place the genus *Eutrochatella* and its related forms in Cuba and southeast Asia into Vianinae.

PYRIMIDINE CATABOLISM BY SOME GASTROPODS

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(Abstract)

The occurrence of β-alanine and β-aminoisobutyric acid in the free amino acids of the tissues of various invertebrates has been put forth as evidence for the operation of the normal pyrimidine catabolic pathway. β-alanine accumulation has been noted in the clam *Rangia cuneata* after injection of uracil, dihydrouracil, and carbamyl-β-alanine (Campbell and Allen, unpublished experiments). Simpson and Awapara (*Biol. Bull.* **117**: 371) found no β-alanine in the free amino acid fraction of several gastropod species. Campbell and Speeg (*Comp. Biochem. Physiol.* **25**: 3) recently reported very small amounts of β-alanine in the free amino acids of various tissues of *Helix aspersa* and *Otala lactea*. Because gastropods are uricotelic to varying degrees, it was of interest to investigate pyrimidine degradation in relation to purine metabolism and method of nitrogen excretion.

When 2-^{14}C-uracil was incubated with hepatopancreas tissue from three prosobranchs, $^{14}CO_2$ evolution was evident in all species in the following order of descending activity: *Littorina irrorata* > *Urosalpinx cinerea* > *Thais haemastoma*. In pulmonates, the capacity for $^{14}CO_2$ evolution from 2-^{14}C-uracil was as follows: *Siphonaria pectinata* > *Limax flavus* > *Lymnaea stagnalis* > *Otala lactea* > *Helix aspersa*. ^{14}C-carbamyl-β-alanine, an intermediate in the known pathway for uracil catabolism, was isolated from hepatopancreas extracts of all the above species after incubation with the radiocarbon labelled uracil (carrier added to quantitate the recovery). Attempts to obtain the

activities of each of the individual enzymes in cell free extracts were unsuccessful with hepatopancreas tissue from *Otala lactea*.

It is concluded that uracil is catabolized by the normal pyrimidine catabolic pathway in gastropods. The gastropods (*Helix, Otala*) having the greatest degree of uricotelism have the least active pyrimidine catabolic mechanism.

REAGGREGATION OF ONE TO MANY ORGANS FROM DISSOCIATED MOLLUSCAN CELLS[1]

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Recently it was reported (Farris, 1968) that ovotestes cells dissociated from adult *Helix pomatia* reaggregate into histologically organized tissue. This phenomenon has been reported previously in only one other group of animals in their adult form—the sponges.

Investigations were undertaken to determine the extent to which the major organs of *Helix pomatia* could be dissociated and reaggregated. The results indicated that nearly all the organs could be dissociated readily employing the same method described for the ovotestes, or minor modifications thereof. Thus the following organs presently can be dissociated and reaggregated in the presence of two carbohydrates plus trypsin: heart, mantle, lung, crop, esophagus, stomach, digestive gland, albumen gland, kidney, heart, intestine, and eye. The nervous system can be dissociated and reaggregated but requires heat for dissociation. The foot can be dissociated, but the presence of copious quantities of mucus as well as its size renders this organ unfeasible for study at this time.

Cells from various organs can be combined and are capable of rapidly sorting themselves back to form tissue typical of the original organ. An example of this behavior can be seen clearly when cells from strikingly different organs are mixed together such as those from ovotestes (typically egg, sperm, connective tissue, gametocytes, and nurse cells) and heart (mainly muscle cells); or albumen gland (white cells) and digestive gland (green-colored cells). Under these conditions the heart and ovotestis are reformed and appear to be separated one from the other by a clear space. The albumen gland and digestive gland are reformed and can be identified easily by the natural color-coding of each organ.

The same type of experiments demonstrated that a large portion of the total snail can be reaggregated when the whole snail (minus the buccal mass and most of the foot is disaggregated into individual cells. The reaggregation requires approximately 3 hours, during which time tissue typical of the eye, intestine, nervous system, digestive gland, mantle and a portion of foot is restituted. Further, evidences of vascularization and spatial rearrangement of the organs can be seen. Cells incorporated into an organ are well differentiated and appear normal; cells in cavities, or not found contained in an

[1] This investigation was supported by a research grant (AI 07364) from the National Institutes of Health, U.S. Public Health Service.

[2] Supported by Public Health Service Fellowship F2-AI-32, 179.

organ frequently have pseudopodia. At present the large size of the reaggregates (2.5 cm) precludes *in vitro* culture for more than a few hours as the nutrient medium is unable to perfuse into the innermost cells and necrosis often occurs in this area. Investigations of methods to allow longer *in vitro* culture of the reaggregates is being undertaken.

(Time lapse movie of pseudopodial activity of dissociated cells.)

SEXUAL DIMORPHISM IN ERYCINACEAN BIVALVES

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and

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The erycinacean family Montacutidae has been characterized by many as being hermaphroditic (Pelseneer, 1911; Thiele, 1935; Oldfield, 1961; Deroux, 1961 and others). Yet we have found within this family three species which show a remarkable degree of sexual dimorphism. The most extreme case is represented by *Montacuta percompressa* Dall, in which males are reduced to spherical, shell-less masses of gonad tissue surrounded by the mantle tissue of the female. In *Montacuta floridana* Dall the males are dwarf (ca. 2 mm) but shelled and possess a disproportionally large foot. They are harbored within the mantle cavity of the female. A third example is shown by an undescribed species of *Entovalva* which lives commensally with a large capitellid annelid (Jenner and McCrary, 1967, species A). The males of this latter species are similar in form and size to those of *Montacuta floridana* and are housed in a slightly enlarged portion of the posterior extension of the mantle which forms a "tail." A clam with a male in the "tail"!

Deroux (1960) has described dwarf males in *Montacuta phascolionis* Dautzenberg but the "adults" of this species are said to be hermaphroditic (Peres, 1937). Perhaps *M. phascolionis* is essentially a protandric hermaphrodite but with the potential for male development shifted in certain individuals so that the male phase is achieved in the "larval" form. Although histological studies have not been made, our three species appear to be strictly dioecious, the males being highly specialized and presumably lacking the potential for further sexual development. The examples described above show a degree of sexual dimorphism unknown in other bivalve mollusks. The range of variation of sexual development seen within this one family offers an inviting field for further study which is contemplated.

SOME PHYSIOLOGICAL ASPECTS OF THE *STROPHOCHEILUS OBLONGUS*[1]

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The gastropod *Strophocheilus oblongus* (*musculus*) is a large phytophagic

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animal found from Panama to southern Brazil. Being a terrestrial pulmonate gastropod it prefers a humid environment with a moist vegetative cover. This animal seems to prefer a nocturnal state, as most of its activity takes place in periods of low-light intensity. It is reported that in the wild state most all activity takes place at night, especially during summer rain showers. It is also reported that the animal hibernates during abnormal seasonal conditions by burrowing into soft, moist soil. However, in the laboratory the animal estivates after eating, mating, or abnormal photoperiods.

The original animals of this colony were collected in the southern part of Porto Alegro, Brazil (through the efforts of Dr. Celso Jaeger, Professor of Zoology, Universidade do Rio Grande do Sul, Porto Alegre), and arrived by air express on September 28, 1966. These animals weighed between 70 and 100 grams; their shells measured, from the anterior mantle edge to apex (long axis), 7.5 to 10 cm; and the foot, when extended, measured 12 to 15 cm long.

Among the many interesting characteristics of these animals are: (1) they are large hermaphroditic terrestrial gastropods; (2) in mating they reflect both male and female roles in chronological reciprocal sequence, resulting in both laying eggs; (3) these eggs, shell and content, are of high calcium content, and the animals' vegetative diet is relatively low in calcium; and hence (4) calcium take-up, storage and mobilization in egg production becomes of considerable interest.

Three pilot studies were initiated to determine the feasibility of establishing a going colony of animals that would supply an adequate number of individuals for future specific research programs. It was therefore necessary to determine certain fundamental facts relative to: (1) food requirements and other necessary factors essential to maintain the animal in a laboratory environment where it is capable of successful reproduction; (2) anatomical relationships, both gross and histological, relative to immature and sexually mature animals; and (3) a method of narcotization and/or anesthesia so as to facilitate various experimental protocols that would involve surgery, tissue studies (i.e., biopsies), or studies dependent on these procedures.

When the original imported animals were brought into the laboratory, they were numbered and individually placed in clear plastic containers (vegetable crispers, 30.5 × 19.5 × 12 cm, or sweater boxes 37.5 × 27.5 × 10 cm). Several kinds of litter (bedding) were used, moist top soil apparently being the best. Many kinds of vegetables (leaf greens, tubers, flowers, etc.) were supplied *ad libitum*. Lettuce, spinach and collards seem to be most satisfactory. All food was individually washed prior to feeding. However, due to the poor keeping qualities of spinach and collards, lettuce became the food of choice. Old food was removed and replaced with fresh food every other day and the litter (bedding) replaced once each week. When the new litter was put in, a petri dish was imbedded flush with the surface of the litter and filled with water. All animals were weighed at the time of litter changing.

An apparently satisfactory diet has been established in that timed mating studies have been made. Under usual circumstances, animals were left together for five days; however, when mating was observed (which occurred often), the animals were placed back into their original plastic containers. The original 54 animals have produced, to date, over 538 eggs in clutches of one to eight with an average of four eggs per clutch. Egg maturation (from

mating to laying) is 19–20 days under normal conditions. More than 197 of these eggs have hatched after a mean incubation period of 49 days at 70–71° F. A few eggs incubated to hatching in 19 days, whereas a few others took as long as 80 days. There has been some infant mortality and other laboratory-reared animals have been used in various experimental procedures.

A comparative analysis of lettuce and spinach is presented which demonstrates some differences in mineral, water and caloric contents. Hemocoelic fluid values of wild-caught animals are likewise compared with laboratory-maintained animals and demonstrate some interesting differences, especially sodium (W.C.[1] 37.8 to 48 m Eq/L[2]), calcium (W.C.[1] 24.5 to 8.2 m Eq/L[2]), magnesium (W.C.[1] 39.2 to 28.0 m Eq/L[2]), and uric acid (W.C.[1] 0.34 to 0.0 mg% L[2]), among the many evaluations made.

The second study comparing the anatomical and histological structures is being re-evaluated.

Technics of narcotization and anesthesia have been developed. In narcotization, animals were induced to drink nembutal in milk (non-fat, dry milk in solution). This procedure was then supplemented with ethyl meta-aminobenzoate (MS 222, Sandoz). This method was satisfactory, but it was subsequently found that nembutal was unnecessary and the animals could be injected with MS 222 directly into the hemocoelic cavity under the anterior edge of the shell.

These studies have been made on apparently the first colony of *Strophocheilus oblongus* in North America.

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[1] Wild-caught Porto Alegre
[2] Laboratory animals

SPIROGLYPHICS: A STUDY IN SPECIES ASSOCIATION

J. P. E. Morrison
U.S. National Museum (Natural History)

The family Vermetidae includes snails of irregular tubular adult shell growth beyond the regular (minute) embryonic shells of the "crawl-away" young. The family was named by Rafinesque in 1815, for the genus *Vermetus* Daudin, 1800. The second genus of Daudin, 1800, *Spiroglyphus,* included two species that excavate a bed in the surface of other marine shells. Mörch in 1861 designated *Spiroglyphus annulatus* Daudin, 1800 as the type species, originally figured on (in) the shell of *Fissurella barbadensis* Gmelin.

The United States National Museum collections in March 1968 included 194 lots of *S. annulatus* from Bermuda and Florida to St. Vincent and Barbados, and from Cozumel Id., Mexico to Curaçao and Aruba, DWI. This species is positively associated with four other marine snail shells that provide a substratum for its entrenchment: *Fissurella nodosa* Born 68.6%, *F. barbadensis* Gmelin 58.6%, *Astraea caelata* Gmelin 33.9%, and *Fissurella angusta* Gmelin 27.1%. It is indifferently associated with at least four other species: *Hemitoma octoradiata* Gmelin 11.7%, *Collisella balanoides* Reeve 10.5%, *Astraea americana* Gmelin 5.5%, and *A. tuber* Linnaeus 3.6%. Occasional specimens may be found on a few other shells from these western Atlantic

shores: *Siphonaria pectinata* Linnaeus 1.8%, *Fissurella rosea* Gmelin 0.9%. Obviously there is no species association between *Spiroglyphus annulatus* Daudin and *Fissurella rosea* when only one of 112 samples of *rosea* showed either *Spiroglyphus* tubes or their scars on the shells.

If the vermetid genera *Stoa* DeSerres, 1855, and *Dendropoma* Mörch, 1861, are not regarded as separate biological entities, they must be listed as synonyms of *Spiroglyphus* Daudin, 1800. The type-species *S. annulatus* Daudin carries as a synonym the name *S. corrodens* Orbigny, 1842.

Dr. Morrison's report was illustrated by color slides of the type-species *S. annulatus* with its shell costate above like a miniature *Epitonium*, and of several other species in their associated substratum shells. Included were figures of the shells and opercula of *Spiroglyphus*, *Stoa*, and *Dendropoma* from Pacific shores.

STUDIES IN THE LIFE HISTORY OF THE NAIAD, *AMBLEMA PLICATA* (SAY, 1817)

Carol B. Stein

The Ohio Cooperative Fishery Unit, The Ohio State University, Columbus, Ohio

AND

Department of Natural History, The Ohio State Museum, Columbus, Ohio

Glochidia of *Amblema plicata* (Say, 1817) were found only from mid-June to early August during this study. Gravid females were placed in individual finger bowls of lukewarm water as soon as they were brought into the laboratory. Within three or four hours the contents of the four marsupial gills were emitted as white "placental masses" through the suprabranchial chambers and the excurrent aperture. These masses were examined microscopically, and those which contained active glochidia were stirred into a small aquarium where they were kept in suspension by strong aeration. Fishes were then placed in this small infecting aquarium and the glochidia attached themselves to the gills and occasionally to the fins and skin of the fishes. The infected fishes were returned to larger holding aquaria, where they were kept until the glochidia metamorphosed.

A. plicata glochidia successfully metamorphosed in approximately nine days at temperatures ranging from 70–75°F. Juveniles were recovered by siphoning the aquarium water and bottom debris through silk bolting cloth, then examining the debris with a binocular dissecting microscope. Metamorphosed juveniles were successfully recovered from infections of Yellow Perch, *Perca flavescens*, and from four species of Centrarchidae: Rock Bass, *Ambloplites rupestris;* Green Sunfish, *Lepomis cyanellus;* Bluegill Sunfish, *Lepomis macrochirus*; and Pumpkinseed Sunfish, *Lepomis gibbosus*. Attempts to infect several species of minnows, catfishes, and gars were not successful. Very few of the glochidia attached either to the gills or the fins of these fishes. No metamorphosed juveniles were recovered from their aquaria. Bluegills which had successfully carried an infection of glochidia through metamorphosis early in the season were later reinfected. All glochidia which

attached to these fish in the second infection were sloughed off within two days. None of them metamorphosed.

During its period of encystment on the fish host, the *A. plicata* glochidial shell does not increase in size or change its shape. The conspicuous single adductor muscle and "larval thread organ" disappear, however, and the young mussel acquires an active ciliated foot, ciliated gill buds, and two small adductor muscles.

Attempts to identify natural infections of *A. plicata* glochidia on wild-caught fishes have not been successful thus far in this study because of the close similarity in size and shape of these glochidia to those of *Elliptio dilatatus.* Both species occur sympatrically and have essentially the same breeding season.

STUDIES ON THE DISTRIBUTION OF PRESUMED HEMOGLOBIN IN BIVALVE MOLLUSCS

Harold W. Harry

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AND

Rice University, Houston, Texas 77001

(Abstract)

Anatomical studies were made on living specimens of 51 species of marine bivalves representing 26 families. Species of the freshwater families Sphaeridae (*Sphaerium, Pisidium* and *Eupera*) and Unionidae (including several species each of Unioninae, Lampsilinae and Anodontinae) were also studied. Presumed hemoglobin was recognized grossly by its characteristic red color. An opaque brick red color present on the surface of the foot of *Dinocardium robustum* is thought not to be hemoglobin. The orange color of the ganglia of *Congeria leucopheata, Polymesoda caroliniana, Dinocardium robustum, Abra aequalis* and *Macoma constricta* is probably not hemoglobin. An attempt is made to relate the presence of hemoglobin to the phylogenetic position of the bivalves studied. No hemoglobin was found in any of the anisomyarian and monomyarian families: Mytilidae (3 species), Ostreidae (2 species), Pinnidae (2 species), Anomiidae (1 species), Pectinidae (1 species), Spondylidae (1 species), and Dreissensiidae (1 species); nor in three species of the Anomalodesmacea: Periplomatidae (2 species), Pandoridae (1 species); nor in several families of lower heterodonts: Unionidae (many species), Sphaeridae (4 species), Diplodontidae (1 species), Montacutidae (2 species), Cyrenidae (1 species). Hemoglobin is present in some families of lower heterodonts (Lucinidae, Crassatellidae). It is present in some species, but not found in others of the higher heterodonts [absent in Corbulidae (1 species), Cardiidae (2 species), Psammobidae (1 species), Petricolidae (1 species), Semelidae (2 species)]. Hemoglobin is present in all protobranchs studied (Nuculidae, 1 species; Nuculanidae, 2 species) and Arcidae (4 species), as well as in the higher heterodont families Mactridae (*Mulinia lateralis,* but not in *Rangia cuneata* or *R. flexuosa*), Tellinidae (*Tellina,* 4 species, *Macoma,* 1 species) and Veneridae [*Pitar, Mercenaria, Cyclinella,* and *Dosinia,* 1 species of each, but absent in *Gouldia* (1 species)].

Presumed hemoglobin has not previously been recognized in the eggs of bivalves, but the pink color seen in eggs of *Nuculana* sp., *Diplothyra smithii, Crassinella lunulata, Mulinia lateralis* and *Donax variabilis* may be that. In stationary somatic tissue, it is found in the gills of all three species of protobranchs, and *Lucina pectinata*; in muscle tissue only in the adductors of *Mercenaria mercenaria*; in ganglia of *Nuculana* sp., *Mulinia lateralis, Dosinia, Cyclinella, Pitar,* and *Mercenaria,* 4 species of *Tellina* and 1 of *Macoma.* It is present in patches in the disc of the mantle of *Crassinella lunulata,* and in the sense organ of the cruciform muscle of *Macoma mitchelli.* Patches of hemoglobin in the mantle margin between the hinge teeth of *Crassinella* (Harry, 1966, Publ. Inst. Mar. Sci. (Texas) 11: 65–89) may be located in sensory nerve ganglia there. Similar patches in *Pitar texasiana* are connected by a nerve, also containing hemoglobin, to the cerebral ganglia. Hemoglobin is found in the blood of *Crassinella* and in the Arcidae, of the species studied. Contrary to abundant reports in the literature, it seems to be present in the fluid, and not the blood cells of the Arcidae, as demonstrated by centrifugation (a technique never previously reported as used in such studies). The centrifuged cell mass is greyish brown, and the cells (again contrary to the literature) show no gross evidence of hemolysis when washed several times with distilled water. The hemoglobin of the blood plasma has a spectral absorption curve very similar to that of human blood. A faint pink color in the blood of *Cyrtopleura costata* initially thought to be hemoglobin, was found to have a spectral absorption curve very unlike it. Centrifugation shows the blood cells of this species also form a greyish brown cell pack, and the pink color remains in the supernatant fluid.

This study was supported in part by NSF Grant GB-2753 and Communicable Disease Center Grant CC-00126.

THE SYSTEMATIC POSITION OF THE ATHORACOPHORIDAE[1]

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Bernice P. Bishop Museum
and
Museum of Zoology, The University of Michigan

(Abstract)

The Athoracophoridae is an aberrant family of South Pacific slugs of apparent phylogenetic isolation and antiquity. The systematic position of this group has been uncertain or subject to argument ever since some of their anatomical peculiarities (e.g., jaws and "lung") were first described (e.g., cf. Mörch, 1865, *J. Conchyl.,* **13**: 275, 391; Pilsbry, 1948, *Mongr. 3, Acad. nat. Sci. Phila.,* **2**(2): 771; Baker, 1955, *Nautilus,* **68** (4): 109–112; Burch, 1968,

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[2] Supported by a Research Career Program Award (No. 5-K3-AI-19, 451) from the National Institute of Allergy and Infectious Diseases, U. S. Public Health Service.

[3] Supported (in part) by Training Grant 5 T1 AI-41 from the National Institute of Allergy and Infectious Diseases, U. S. Public Health Service.

J. malacol. Soc. Austr., **11**: 62–67). Some workers have considered them as a separate order (Tracheopulmonata) of uncertain affinities. Others have placed them in the stylommatophoran order Heterurethra, as a family, a superfamily, and even as a subfamily of the heterurethran Succineidae.

Burch (1968, *op. cit.*) has shown that tentacular structure and mode of tentacle retraction in the Athoracophoridae are different from that described in other Stylommatophora, indicating that these slugs may be quite distinct. However, we have recently studied in detail the tentacular retraction of Succineidae (*Catinella, Succinea, Oxyloma, Omalonyx*), as well as various anatomical characters (e.g., tentacles, body surface characters, pedal grooves, pulmonary cavity, male genitalia), and we conclude that the Athoracophoridae are related to the Succineidae, and should be included with them in the same stylommatophoran suborder. Several other workers have reached the same conclusions from a study of different characters (Mörch, 1865, *op. cit.*; Baker, 1955, *op. cit.*; Van Mol, 1967, *Mem. Acad. roy. Belg.*, **37**(5): 1–168).

The demonstrated relationship between the Athoracophoridae and the Succineidae leads to the problem of their relationship to the Stylommatophora, where the Succineidae have traditionally been placed. Pilsbry, (1900, *Proc. Acad. nat. Sci. Phila.*, pp. 561–567), in dividing the Stylommatophora into suborders, separated the Succineidae from the Orthurethra and the Sigmurethra as the suborder Heterurethra. Butot & Kiauta (1967, *Beaufortia*, **14** (174): 157–164) maintain that the Succineidae should be removed from the Stylommatophora. They advocate raising the Heterurethra to ordinal rank, but retained Baker's (1956, *Nautilus*, **69**(4): 128–139) superfamilial name Succineoidea. However, their reasons for this taxonomic separation seem to be based on superficial characters. For example, 1) succineid and basommatophoran tentacles are structurally and functionally quite different regardless of their broadened bases; 2) a discrete "prostate" gland not only occurs in the Succineidae, some opisthobranch and basommatophoran snails, but also in such Stylommatophora as the orthurethran family Achatinellidae; 3) not all succineids lay their eggs in masses, but when they do, they differ basically from those of the Basommatophora (incidentally, eggs of *Succinea ovalis* are laid singly and are attached to each other by a single, very thin, relatively long gelatinous thread); 4) the 3-ducted type of reproductive tract of *S. putris* occurs not only in opisthobranchs, but also in the Basommatophora and most likely in many Stylommatophora as well; 5) Cook (1966, *Arch. Néerl. Zool.*, **17**(1): 1–72) contends that in most respects the central nervous system of *S. putris* is typically stylommatophoran in character; 6) the basal flange of the jaw of the Succineidae and Athoracophoridae is an interesting modification, but the elasmognathan jaw is less different from that of the other Stylommatophora than the differences exhibited in jaw structure *within* some of the basommatophoran families (e.g., the Planorbidae); 7) chromosome numbers of the Heterurethra (= Elasmognatha) ($n = 5$ to $n = 44$) *per se* do not indicate that a major systematic separation at the ordinal level is justified, especially at this stage in our knowledge about chromosome numbers in euthyneuran snails (less than 3% of the recent species of Euthyneura have been studied; there is no information on 59% of the families; and not a single species has been studied in 5 of the orders).

In our investigation, we found that the Succineidae seem to possess many characters intermediate to the tracheopulmonate slugs on the one hand and to

the remaining Stylommatophora on the other, and accordingly, the Succineidae would seem to be an ideal ancestral type to both groups. Specialized structures in the tracheopulmonate slugs and the other Stylommatophora can be derived from less specialized ones in the Succineidae.

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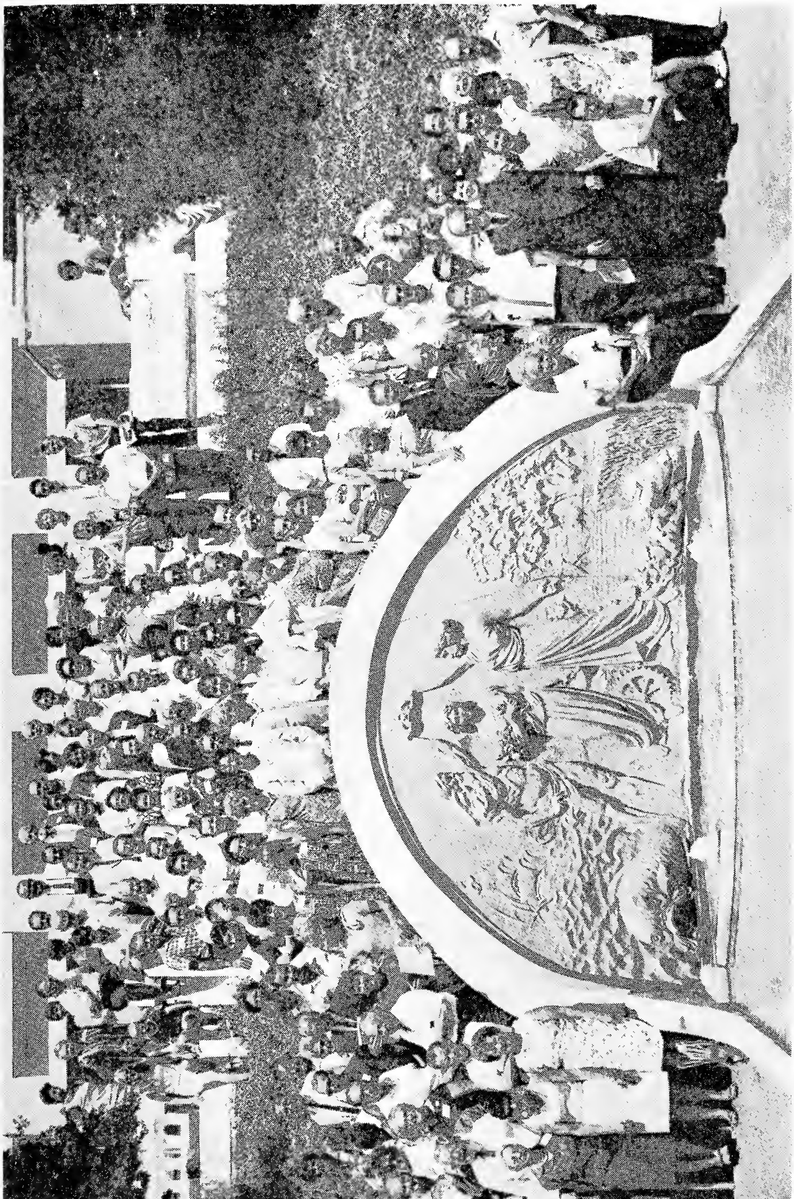
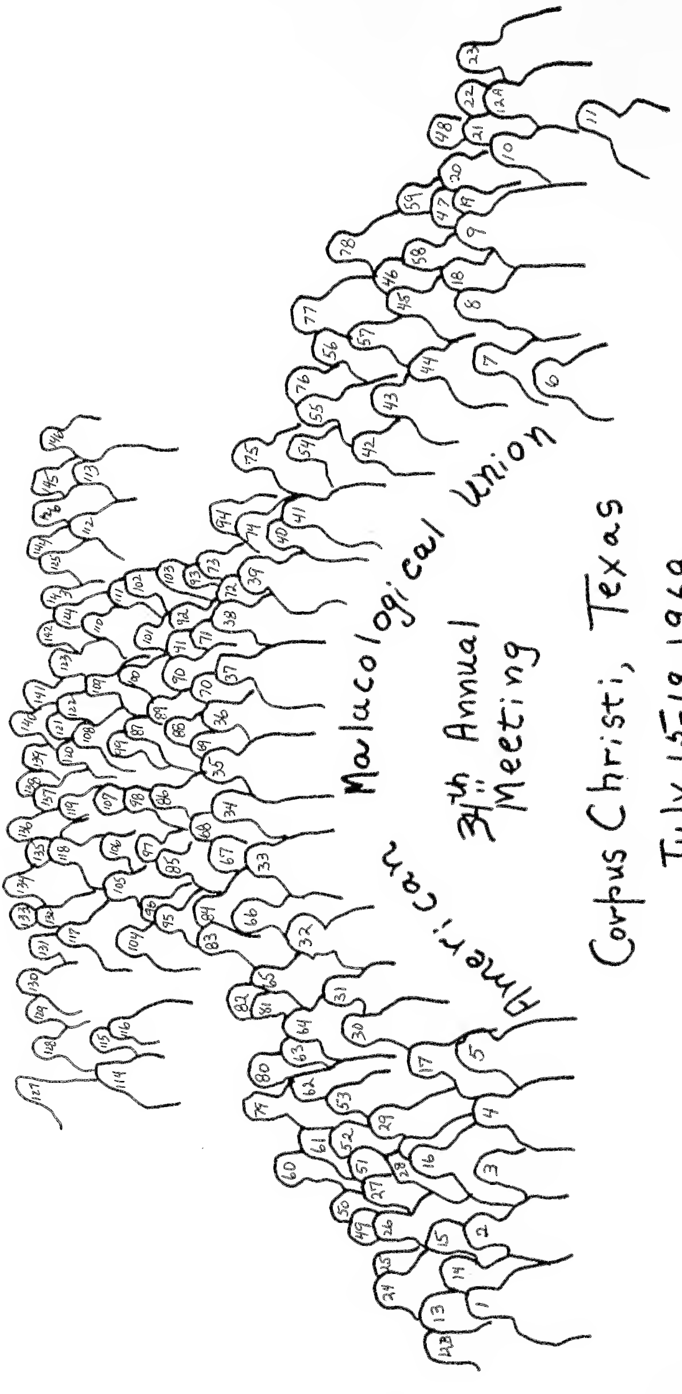


AMERICAN MALACOLGICAL UNION
Thirty-fourth Annual Meeting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THE AMERICAN MALACOLOGICAL UNION PACIFIC DIVISION, TWENTY-FIRST ANNUAL MEETING

The Pacific Division of the American Malacological Union met at Asilomar, Pacific Grove, California June 19–21, 1968. The detailed program of former years was foregone but a business meeting was held, attended by the following PD members:

Edwin C. Allison, Twila Bratcher, Beatrice Burch, G. Bruce Campbell, Crawford Cate, Jean Cate, Elsie Chace, Emery Chase, Eugene Coan, Helen DuShane, Ruth French, Barbara Good, Myra Keen, Mary Long, Virginia McClure, James McLean, Mae Dean Richart, Gale Sphon, Rudolf Stohler, Robert Talmadge, Judith Terry, Fay Wolfson.

MINUTES OF THE BUSINESS MEETING—June 20, 1968

The Business Meeting of the 1968 Conference of the AMU-PD was called to order by Chairman Fay Wolfson at 3:45 p.m. on Thursday, June 20, 1968 in Merrill Hall, Asilomar, Pacific Grove, California. Present were the following:

Edwin C. Allison, Twila Bratcher, Beatrice Burch, G. Bruce Campbell, Crawford and Jean Cate, Emery and Elsie Chace, Eugene Coan, Helen DuShane, Ruth French, Barbara Good, Myra Keen, Mary Long, Virginia McClure, James McLean, Albert R. Mead, Mae Dean Richart, Gale Sphon, Rudolf Stohler, Robert Talmadge, Judith Terry, Fay Wolfson.

It was moved, seconded and carried unanimously that the minutes of the 1967 Business Meeting be accepted as printed in the 1967 Annual Report.

The Treasurer presented her report, which showed a balance of $332.50, with additional expenses remaining to be paid from this amount before the close of the fiscal year. It was moved, seconded and carried that this report be accepted, subject to review by the Auditing Committee.

A letter was read from the AMU Secretary, dated November 10, 1967 reporting two motions passed by the Executive Council at its Annual Meeting. They are as follows:

"After discussion the motion was made, seconded and carried that the Pacific Division be petitioned to discontinue levying its annual assessment upon those AMU life members whose life status (paid or honorary) was established before the current Pacific Division by-laws were adopted.

It was further moved, seconded and carried that the Pacific Division be requested to amend the by-laws to exempt those AMU members with Navy or APO addresses in the Pacific area from involuntary Pacific Division membership unless their permanent home address is in Pacific Division territory, and that the geographical boundaries of the Pacific Division be expanded to include residents of the Pacific Northwest, Alaska and Mexico with a view to increasing Pacific Division membership."

Further discussion on this matter was postponed.

The Chairman announced that the Pacific Division Award of Honor would be presented at the banquet.

Discussion was invited regarding the 1969 AMU-PD meeting, taking into consideration that a new organization with similar aims would be holding a conference at the time and place usually scheduled for the AMU-PD meeting.

It was moved and seconded that the AMU-PD would hold its 1969 Business Meeting coincident with the annual meeting of the Western Society of Malacologists. After thorough discussion of the status, prospectives and objectives of the two organizations, the motion was carried.

It was moved, seconded and carried that the new officers of the Pacific Division be instructed to act in a "caretaking capacity" for the AMU-PD.

It was moved, seconded and carried unanimously that the resignation of this year's officers, given at a meeting of the Executive Board in December 1967, not be accepted, and that they continue to perform their duties until their term of office expires.

It was moved, seconded and carried unanimously that the Pacific Division send Chairman Fay Wolfson as its representative to the AMU Meeting at Corpus Christi at the expense of the Pacific Division, such expenses to cover transportation, lodging, food, and registration fee.

It was moved, seconded and carried unanimously that the Chairman be instructed to carry out at the Corpus Christi AMU Meeting the wishes of the Pacific Division Meeting as indicated in the discussion and votes of this meeting.

Chairman Wolfson appointed Dr. Rudolf Stohler as Mentor-Parliamentarian for the coming year.

The Chairman advised that an Auditing Committee would be appointed within a week.

The Nominating Committee, consisting of Robert Talmadge, Chairman, Elsie Chace and Dr. Myra Keen, presented the following slate of nominees:

Chairman, Dr. Bruce Campbell
Vice Chairman, Dr. James McLean
Secretary, Ruth French
Treasurer, Ruth French

As there were no further nominations from the floor, it was moved, seconded and carried that the Secretary be instructed to register a unanimous vote for the slate of officers as presented.

It was moved, seconded and carried unanimously that the Pacific Division assessment be rescinded.

As there was no further business, it was moved, seconded and carried that the meeting be adjourned.

Meeting adjourned at 4:55 p.m.

Respectfully submitted,
Barbara Good, Secretary, AMU-PD

PACIFIC DIVISION EXECUTIVE BOARD 1968–1969

Chairman .... G. Bruce Campbell
Vice-Chairman .... James H. McLean
Second Vice-Chairman .... (none elected)
Secretary and Treasurer .... Ruth French
Executive Board .... Alan J. Kohn, Gale G. Sphon, Jr., Fay Wolfson

NEWS, NOTES, NOTICES

THE THIRTY-FIFTH ANNUAL MEETING of the American Malacological Union will be held July 21–25, 1969 in Marinette, Wisconsin. Headquarters will be the Silver Dome Motel located on Green Bay (Lake Michigan) and adjacent to the campus of the University of Wisconsin Extension Center whose modern auditorium will be available for all sessions.

Full details, rates, reservation forms, call for papers, etc. will be mailed to all members in April with an absolute reservation deadline of May 30.

This promises to be a well attended and enjoyable occasion and anyone in any degree interested in mollusks or their shells is cordially invited.

The AMU Pacific Division will meet in conjunction with the Western Society of Malacologists at Asilomar on a date to be announced; those interested in attending should contact Secretary Ruth French, 24213 Eshelman Avenue, Lomita, California 90717.

* * *

We apologize for the high percentage of unidentified persons appearing in the group photograph on page 53, as well as to any who are mis-identified. The blame must be placed on several factors, not least the fierce Texas sunlight which caused the photographer's subjects to squint involuntarily. Those who wore the dark glasses included in the gift handouts succeeded nearly as well in disguising themselves beyond recognition.

* * *

The continued pressure of rising publications costs is forcing the American Malacological Union in 1969 to adopt a policy of page charges for papers included in the Annual Report. Most of the leading scientific journals published by societies analogous to the AMU have taken similar steps in recent years. Charges per page will be made concordant with current printing rates.

We believe that the policy of most institutions is to consider such charges a necessary factor in research costs, or that grant funds will provide this subsidy for the AMU program. No abstract nor summary will be refused publication because the author does not have funds for publication charges; if funds are unavailable the AMU will absorb the costs of printing such contributions. However, since 95% of AMU dues goes into printing and mailing costs for the Annual Report, authors are urged to make every effort to secure the necessary financial support.

THE THIRD EUROPEAN MALACOLOGICAL CONGRESS

Albert R. Mead

The Third European Malacological Congress was held at the Naturhistorisches Museum in Vienna, Austria, from September 4th to September 7th, 1968. Previous to this, on September 2nd and 3rd, there was held a pre-congress Symposium on "Molluscs as Parasites or their Transmitters." The vast majority of the 177 registered participants for the Congress were present to hear President Dr. Oliver E. Paget's welcome to the Symposium, which he delivered in German, English and French. The papers started right out with much vigor, enthusiasm and audience response, and with few exceptions, they stayed that way throughout the total of 15 half-day sessions of the Symposium and Congress.

Dr. Paget's Presidential Address, delivered in German, officially opened the Congress midmorning on September 4th. His address, for which there were English and French résumés, was short; but its eight point list of recommendations provided a sober challenge and genuine stimulus to those present—quite in contrast to the conventional presidential address, steeped in academia and esoterica. For many, the highlight of the opening ceremonies was the formal visit to the remarkably extensive and complete Mollusk Section in the areas open to the public in the Naturhistorisches Museum. Most people were torn between examining the excellent exhibits and visiting with all sorts of new friends and old friends, many of whom they had not seen for a long time. At least one person became confused in the process and was caught walking out with one of the exhibits. I was then told that the blond fräulein was NOT an exhibit, but one of the official museum guides. Things can be so confusing in foreign lands!

The roster of registrants, distributed at the beginning of the Congress, indicated that 32 countries were being represented. Austria, Netherlands and the U.S.A. lead with over 20 registered participants each. Following in order were West Germany with 17, England with 14, France with 11, Italy with 10 and Russia with 8. Four each were registered from Wales, Scotland and Canada. Sweden, Norway, Denmark, Switzerland, Hungary, Rumania and India had three registrants each; Yugoslavia and Poland each had two; and one each was registered from North Ireland, Belgium, Portugal, Spain, Malta, Israel, Egypt-UAR, Ethiopia, Algeria, Nigeria, South Africa and Brazil. Between the sudden difficulties in Czechoslavakia (the border is only 30 air miles away from Vienna!) and the enforced austerity in research grant funds, along with absolutely no help for anyone this time from the usual Washington, D.C. travel fund source, it was no great surprise, but none the less a great disappointment, that an inordinately large number of our AMU colleagues and a fair number of our correspondents in the Iron Curtain countries simply did not show up, in spite of the fact that in some cases their names appeared on the official roster of participants.

AMU members in attendance were: Kenneth J. Boss, Harvard Museum of Comparative Zoology; John B. Burch, University of Michigan; Arthur H. Clarke, National Museum of Canada; Dee S. Dundee, Louisiana State University; Walter J. Eyerdam, Seattle, Washington; Louise R. Kraemer, University of Arkansas; John A. Krause, University of Connecticut; Albert R. Mead,

University of Arizona; Walter B. Miller, University of Arizona; Joseph P. E. Morrison, U. S. National Museum; Juan J. Parodiz, Carnegie Museum; Henry van der Schalie, University of Michigan; Alan Solem, Field Museum of Natural History; and Rudolf Stohler, University of California. The names of the other U. S. participants appearing on the official list were: Martyn Apley, Woods Hole Oceanographic Institution; Brenda Baumann, Pittsburgh; Earl R. Chesler, Ft. Lauderdale, Florida; Emile S. Demian, Harvard University; Frank J. Etges, University of Cincinnati; Lilburn Hettick, Oklahoma; Martha Klinkey-Barr, Batavia, Illinois; and Copeland MacClintock, Peabody Museum of Natural History. Prominent among European notables in Malacology were: Caesar R. Boettger, G. I. Crawford, Stanley Peter Dance, Bengt Hubendick and many more than can be listed here. Most regrettably, C. O. van Regteren-Altena had to cancel plans to attend the meetings and W. S. S. van der Feen-van Benthem Jutting could not come because of illness.

Dr. Oliver E. Paget, who was President, Chairman of the Organizing Committee, Curator at the Naturhistorisches Museum in Vienna, Coordinator of all aspects of the multifaceted program, Chief Trouble-shooter, Principal Interceptor of Emergencies, Expeditor *par excellence*, Provider of the Fee-free Phone, Chief Morale Office, Guardian of the Esprit de Corps, Multilingual Announcer, Chief of Protocol, and gentle Commiserater for lost causes and hopeless cases, did an absolutely magnificent job of appearing to be all places at once and yet remaining graciously attentive to the small details of the problems of the many people who seemed to intercept him on every turn. Unfortunately, the International Philosophical Congress was held in Vienna contemporaneously with our meetings; and the resultant tight situation and conflicts provided more than the usual amount of unavoidable difficulties. Chief among these was the scheduling of the three concurrent section meetings in three different buildings, 2–3 blocks and considerable city traffic away from each other. This separation, plus the inevitable last-minute irregularities in programs (cancelling papers, switching papers, over-long papers, etc.) made it next to impossible to try to transfer from one section to another without running the risk of missing out altogether. For some of us, this was a rugged exercise in frustration.

In general, the chairmen of the individual sections kept fairly close to the generous time schedule. The time allotted to questions and answers functioned as a buffer period that could either be used as intended, or irretrievably consumed by those who became inebriated by the exuberance of their own verbosity. In some sections, the Chairman or the local committeeman "On Duty" presented at the close of each talk an impromptu summary in one or more languages. Most of the papers were presented in English, a fair number were given in German and a few were given in French. Of the 76 abstracts handed out at the time of registration, 55 of them were in English, 13 in German, 7 in French and 3 in both English and German. For those of us who are not fluent with German, there were pretty fair difficulties. One in particular stands out in my mind. After listening to German reports all morning and hearing their word for "snails" (schnecken), I staggered to the nearby Volksgarten for lunch and instead of ordering my favorite ham omelet (schinkenomelette), much to the horror and disbelief of the waitress, I ordered "schneckenomelette"! In one other instance, the word for slug "nacht-schnecke" (= night-snail) got all wound up in the fact that it is *not* (nicht) a

snail (schnecke)—and they stood there in amazement when in desperation I asked for the nearest "wunderbar"! When it comes to mixing up languages, it is awfully easy to commit a *faux pas* in German, n'est-ce pas?

The nine papers listed for the Symposium and the 72 papers listed for the Congress ranged from general to specific, from cytological to conchological, from pathological to zoogeographic, from taxonomic to behavioral, and from French to German. Everyone had his own ideas as to what was the most interesting papers and the most exciting new research in malacology; but several independently were heard to register great enthusiasm over the reproductive and neurophysiological investigations of Dr. Joos Joosse and the ultrastructural research of Miss Elizabeth Meuleman—both from Free University in Amsterdam. It is easy to predict that malacological studies at that university and at the University College of North Wales, where Dr. Norman Runham has his little group, will open within the next very few years wholly new vistas in some of the more complex studies of molluscan microanatomy and physiology.

The terminal General Assembly meeting was prolonged and dominated by the many ideas and suggestions that grew out of Dr. Paget's eight point presidential address. The end result was an historical broadening of the scope and a refining of the aims of Unitas Malacologica Europaea. As a member of the Council, Dr. Bengt Hubendick made the very welcome suggestion for future meetings that papers not be allowed to run contemporaneously, but instead that they be offered seriatim as *brief* reports on the essence of the research, without detailed data but with the understanding that similarly interested persons would converge in separate discussion groups to pour over the details of the data at whatever length they might want. Dr. Hubendick pointed out the truism that it is this sort of communication that contributes the greatest scientific and personal value at any national or international meeting. It was announced that once again through the generosity of Dr. John Bayard Burch, the abstracts of the Symposium and Congress would be published in a special issue of MALACOLOGIA.

And while the papers were going on, wives and families were busily taking guided tours through Vienna Woods, the Porcelain Factory, Schönbrunn Palace, Stadt Park and dozens of other places in and around Vienna. The four different guided excursions, primarily for the participants, were scheduled to run concurrently with some of the section meetings. This unfortunately cut down on the attendance in both functions and caused considerable distress to those who dearly wanted to be in two places at once.

The receptions at the palacial Rathaus of the Lord Mayor of Vienna and at the stately Naturhistorisches Museum were elegant beyond description—brilliant crystal chandeliers, huge ornate rugs, more marble than in all the state of Vermont, ornateness and rococo in interior decorations until the eyes danced (in that country, they *really* "go for baroque"!), gourmet goodies in endless variety, tempered bacchanalia, good friends and delightful repartee. The legendary festivity and hospitality of Vienna became realities! And all this all over again at the Banquet held the last night in the fabulous Rathauskeller.

Malacologically, socially and spiritually the Third European Malacological Congress was an outstanding success. We parted with renewed enthusiasm, with new ideas and techniques for our research, with new friends, and with

solemn vows to start saving our pennies for the Fourth European Malacological Congress to be held in 1971 in Geneva, Switzerland, under the very able direction of Dr. Eugene E. Binder, the new President of Unitas Malacologica Europaea. As for me, I still wish I could have taken home one of those exhibits!

SHELL CLUBS AFFILIATED WITH THE AMERICAN MALACOLOGICAL UNION

BROWARD (FLORIDA) SHELL CLUB, Mary Palmer, Corresponding Secretary (Acting): The Broward Shell Club wishes to extend a cordial invitation to all visitors and members of other shell clubs to attend its monthly meetings held every second Wednesday at 8:00 P.M. in the Community Room of the Atlantic Savings and Loan Association, 1750 East Sunrise Boulevard, Ft. Lauderdale, Florida.

This past year members were given magic carpet treats when guest speakers included Mrs. Thelma Hartley. A co-founder of the Malacological Society of Australia founded over 15 years ago, Mrs. Hartley easily transported members from their chairs to the shores of that continent with her vividly descriptive narration and beautiful slides.

Mr. Earl Chesler sent us winging toward the east and we found ourselves inside the British Museum, viewing seldom seen magnificent rare specimens. Museum officials unlocked the vaults to allow Mr. Chesler to photograph these shells but only from a respectful distance. The Broward Shell Club would like to acknowledge and express its appreciation to the British Museum for this kind courtesy.

Miss Frances Hutchings took the jolting swampbuggy ride deep into our native Florida Everglades for us to bring back pictures of the rare beauty within its boundaries. Certain species of the beautiful tree snail, *Liguus*, almost extinct by the swaths of civilization, are making a strong comeback with the protection of Park Rangers.

Mrs. Betty Stapleton provided us with a delightful trip embracing Mexico and acquainted us with the various shells of its shores.

Snorkeling and diving are increasing in popularity with members and we were fortunate to view for the first time a living *Umbraculum* obtained by Jim Ingalls.

Shell hunts, our annual Christmas dinner party, working with the South Florida Shell Club on a shell bazaar have kept members happily busy. The response of the number of exhibits at our fourth annual shell show was tremendous. We were very fortunate in having Dr. Tucker Abbott and Mrs. Germaine Warmke as judges.

By means of exhibiting collections, donations of shells and classroom visits, members are finding an increasing interest of elementary school children in conchology. We hope that our endeavors will stimulate and project these junior citizens into the closely allied marine sciences, whereby the survival of mankind in the future may be determined.

Current officers are: President, Mr. Bill Chapman; Vice-President, Mr. Philip Winston; Rec. Sec'y., Mrs. Betty Stapleton; Corres. Sec'y., Mrs. Alice McLaughlin; Treasurer, Mr. Al Curth.

BUFFALO CONCHOLOGICAL SECTION OF THE BUFFALO SOCIETY OF NATURAL SCIENCES, Ellen Holdway, Secretary: Our past year's activities have been varied. September was banquet time at Lyons Tea Room where beautiful shell bouquets and the pearly Nautilus were displayed. In October Reverend Leslie and Mrs. Eunice Potter gave us an illustrated talk on

Tusk Shells. This month also brought a request for American shells from the Mariners Training School for orphan boys in Ostend, Belgium. Two boxes were dispatched and we in turn received shells from the Belgian coasts. November was dredging time, coral beds yielding one or two prizes; dredgings are always fun. The new year brought election time, with only one change: Officers are following: Mrs. Joseph Wandyez, President; Mrs. Ethel Bishop, Vice-President; Miss Louise Becker, Treasurer; Mrs. Ellen Holdway, Secretary; Mr. Lester Greene, Librarian.

Mrs. Bishop brought new ideas to the group; we now have a "Personality" and a "Shell of the Month." Up to the present time we have learned a little of the lives of Mrs. Teskey, Mrs. Robertson and Mrs. Hoffmann, all past members of this club. The shells discussed were *Murex* and fresh-water mussels, plus a talk on coral. Mrs. Hertendy gave a paper on *Fasciolaria tulipa* grown in a small aquarium.

February was film time: Pond Life, Pirates of the Deep, Sponges and Coelenterates, and our own shell film. This month also brought the sad news for us that the Rev. and Mrs. Potter would be leaving this area in May after a wonderful association for a number of years. They entertained us at a delightful dinner and shell display and exchange at their home in March. In April the late Eugene Schmeck's large collection was given to the Museum by his sister and we were privileged to see it.

May brought a surprise visit from Mr. Sadao Kosuge, malacologist from Tokyo. While a little difficult to follow verbally, he wrote and illustrated perfectly in English. We learned much from this very pleasant ambassador from Japan. We end this part of the year in June with a fossil hunt and picnic conducted by Mr. Stanley Adamski.

CHICAGO SHELL CLUB, Toni Wood, Corresponding Secretary: This has been a busy and enjoyable year. In January an excellent color film was featured, "The Sea," produced by the International Oceanographic Foundation; also we had a shell exhibit at the Downtown Chicago Library. In February Donald Bosch, M.D., presented a slide-illustrated talk on Shelling in Muscat, Oman. Two excellent color films were enjoyed in March, "Coral Wonderland" and "Mysteries of the Deep," which disclosed Australia's marine wonderland.

During the entire month of March the club held the fourth annual Shell Show at the Field Museum. The theme was "The Geography of Shells," and the show was well attended and thoroughly enjoyed.

In April the club viewed one of Jean Cate's Shellectures which featured a trip the Cates had made to Batangas Bay in Southern Luzon, and in May "Below the Tide" transported viewers to collecting areas around Guaymas in West Mexico. On the program for June was another of our famous silent shell auctions which netted our treasury $139.10 and provided many choice shells to lucky bidders.

The current season opened in September with another slide presentation, "Muricinae and Ocenebrinae." Our meetings are held at the Field Museum on the second Sunday afternoon of each month and our officers are: President, A. J. Lindar; Editor, Alice Burke; Corresponding Secretary, Toni Wood, Treasurer, Ruth Swenson.

CONNECTICUT VALLEY SHELL CLUB, Ruth H. Warren, Recording Secretary: 1967–68 was another busy and interesting season. We now have 35 regular and eight honorary members and meet on the second Monday of each month at the Springfield (Massachusetts) Science Museum or in members' homes. 1968–69 officers are: Helen Burt, President; Earl Reed, Vice-President; Charles Bingham, Treasurer; Ruth Warren, Recording Secretary; Priscilla Bingham, Corresponding Secretary.

For the July, August, and September meetings we took to the road for Sunday basket lunch outings at the summer homes of three of our members. At several of the meetings members provided the entertainment: Connie Glassanos told of her shelling vacation in Florida, Earl Reed gave two illustrated talks on "Cowries," "Rare Shells and Land Snails" and the Robert Leys told of their trip through parts of Portugal, Spain, Africa, and Brazil. At other meetings speakers were Dr. Ruth D. Turner of Harvard who spoke on oceanographic research, Mr. Ravosa who told of shell collecting in Guam and Mr. Rivest of Seivers Divers—all most interesting. The December Christmas party was not too well attended because of illness and bad weather; then an ice storm cancelled out the January meeting. However, the Dow's Open House in May to see their fabulous shell collection from their trip to California, Mexico, Texas, and Florida finished out the year in fine style.

The big work project of the year was construction of shell display cases for the blind of Perkins Institute in Watertown and the Greene Unit of Waltham State Hospital in Massachusetts. The project was started and carried through by Mildred and Ken Page while the rest of us did the easy, easy part—donated the shells. The project was given a splendid illustrated write-up in the January, 1968 issue of "Our Dumb Animals."

Ours is a comparatively small club but we are a very active and enthusiastic group.

GALVESTON SHELL CLUB, JaNeva Porter, Secretary: The club, starting its third year, meets on the third Tuesday of the month at 7:30 P.M. at the William Temple Foundation. At the May meeting the following officers were elected: President, Mrs. Laura Herman; Vice-President, Mrs. Laura Barnes; Secretary-Treasurer, JaNeva Porter.

Our programs this year have included films, lectures by visiting collectors, exhibits by members and a tour of the Bureau of Commercial Fisheries. As a money making project, two frames of shells were made and sold for display to the Flagship Family Hotel here in Galveston.

We publish a newsletter devoted to membership news and activities, and scientific information concerning shells. Plans for the coming year include a shell fair (our first), shelling trips to surrounding beaches, trips to shell fairs in nearby communities, the AMU convention at Corpus Christi, and intensification of public relation efforts to publicize the club and its activities.

We now have a membership of 22 adult members and 5 junior members. Dr. Harold Harry of the Texas A and M Marine Laboratories is our advisor.

HOUSTON CONCHOLOGY CLUB, Mrs. George D. VanErp, Corresponding Secretary: The club meets on the fourth Wednesday of each month from

August through May at 7:30 P.M. at the Southwest Service Center. Other officers are: Laurence N. Dexter, Chairman; Tom L. Kister, Vice-Chairman; Mrs. J. M. Fennessy, Recording Secretary; Mrs. David A. Dashiell, Program Chairman; Dr. Helmer Odé, Editor; and Dr. T. E. Pulley, Consultant.

The club has had an active year. Programs included illustrated talks, workshops and beachcombing trips to coastal areas. Plans were made to join forces with four other coastal shell clubs to host the 34th annual meeting of the American Malacological Union at Corpus Christi in July. The club's third annual shell show featured many beautiful and educational displays and a very popular exhibit of live mollusks and other marine life.

Considerable progress can be reported on the mollusk survey which was begun about two years ago. This population survey covers bay areas between the mouths of the Rio Grande and the Mississippi rivers and Gulf areas out from shore to a depth of several hundred fathoms. This work is being done in co-operation with the Houston Museum of Natural Science and the Galveston Biological Laboratory of the Bureau of Commercial Fisheries. Dredged samples are sorted by the club members who are working on the project and over 10,000 lots have been roughly identified and catalogued. Precise identification has begun. The collection shows a wealth of species not yet reported from this part of the Gulf and presumably there are several undescribed species. Some typically Caribbean species have been collected from coral banks (the Flower Garden) some 120 miles east of Galveston.

The club's publication—"Texas Conchologist"—is a monthly bulletin devoted to membership activities and scientific information concerning shells.

THE INTERNATIONAL LEAGUE FOR YOUNG SHELL COLLECTORS, Edgar Bauer, Exec.: The ILYSC was organized in 1967 by two college students who have a great interest in conchology and malacology and want to encourage other young people in the study of shells. As there can be no meetings, members have contact through their mimeographed paper, THE YOUNG SHELL COLLECTOR'S QUARTERLY. It provides information and literature on shells, encourages exchanging of shells and ideas internationally, and furnishes advice to those interested in malacology as a career. Professional advisors are: Drs. William J. Clench, R. Tucker Abbott, Kenneth Boss and Mr. Morris K. Jacobson, U.S.A., and Bro. Mark Ross, S.M., Peru, S.A. The QUARTERLY'S staff includes Edgar Bauer, Editor and Publisher, Lima, Peru; Steven J. Britz, Treasurer, Watertown, Mass.; Patrick Anseeuw (European Division), Courtrai, Belgium; and Mrs. Edwin S. Hicks, 7170 Lucky Drive W., Jacksonville, Florida 32208, Public Relations. Four very informative and illustrated issues of the QUARTERLY were mailed to members in seven countries during the past year. We welcome all inquiries.

MIAMI MALACOLOGICAL SOCIETY, Ellen Crovo, Corresponding Secretary: We meet on the second and fourth Fridays of each month: one a short business meeting, lecture or program when available, followed by a study period of learning, comparing and sharing specimens and information. The second meeting is completely devoted to study.

We make our information and observations available upon request to

scientists along with specimens needed for study or comparison. Many of our foremost scientists are tied to their offices, relatively speaking, unable to go into the field as much as they could wish. Therefore our eyes and legs can provide much valuable information.

At present our efforts are bent on providing certain mollusks to aid cancer research at the Variety Childrens Hospital Research Foundation in Miami.

Any request within our ability to answer is immediately announced to the membership as a project. Our President, Lt. Col. Corinne E. Edwards lectures at schools with her "Show and Tell" on Marine Life, also to the blind and underprivileged.

All members provide available specimens for radula studies, photography and comparison as needed. Any specimens we can obtain in series without depleting an area are sent to various museums and institutes of learning with all pertinent data as to locale, associated fauna and foods available.

Our field trips are mainly to make observations, to obtain requested specimens and fill in vacancies in our own scientific Florida collections. Our QUARTERLY publication, free to members and honorary members, are available through corresponding membership.

We do not have shell shows, though many members have won ribbons in other club shell shows. Our President won the Philadelphia Award Trophy this year with her complete study of the *Busycon contrarium* in less than eight feet of space at the Palm Beach County Shell Club Show.

Officers will be glad to hear from anyone interested in our activities. President, Lt. Col. Corinne E. Edwards, Box 691, Miami, Florida 33133. Vice President-Corresponding Secretary, Mrs. L. E. Crovo, 2915 S. W. 102 Avenue, Miami, Florida 33165. Secretary, Mrs. Guy Webb, 1671 N. W. 111th Street, Miami, Florida 33167. Treasurer, Mrs. E. W. Futch, 144 West 32nd Street, Hialeah, Florida 33012. Editor-Historian, Mr. John A. Baker, Box 4524, Patrick Air Force Base, Florida 32925.

NAPLES (FLORIDA) SHELL CLUB, INC., Lena L. Cartwright, Corresponding Secretary: We have had a very enthusiastic atmosphere at our meetings this year and seventy new members have been added to our membership list, making our total 155.

No doubt our annual shell show requires the most attention and work, but everyone is willing and ready to do their share. This year, February 23–25, 1968, the attendance was over 6,000. The financial success assures us of continuing our $500 Wm. H. Cole Scholarship to a member of the senior high school class going on to college and majoring in biology. We have already set February 21–23 as the dates for our 1969 show.

The *Naples Shell News* has been published monthly from October to April with eight pages of interesting articles submitted by club members. Associate editors Mrs. Bea Cole and Mrs. Laverne Weddle with Mrs. Ruth Martin as manager.

New this year have been four organized shelling trips with an attendance of from 30 to 50, three by boat to nearby islands and one by car to Sanibel. They have added greatly to the sociability among members as well as a desire to add to our knowledge of serious collecting.

Our meetings are held on the third Thursday of each month October to

May. At the March meeting the following officers were elected: President, Mrs. Louis Carey; Vice-President, Mrs. George Miller; Recording Secretary, Mrs. Edward Foster; Corresponding Secretary, Mrs. Robert Richardson; Treasurer, Mrs. Earl Martin. Board members at large, Col. Robert Baker, Mr. Jerome Bijur, Mrs. Lloyd Green and immediate Past President, Mrs. J. Richey Horner.

NATIONAL CAPITAL SHELL CLUB, Peg Carpenter, Secretary: Officers were Walter N. Carpenter, President; Norman Meese, Vice-President; Mrs. Walter N. Carpenter, Secretary; Mrs. Elsie Davison, Treasurer; Mrs. Bessie White, Historian; Dr. Harald A. Rehder, Scholarship Chairman.

We meet the last Thursday of every month, September through May, in Room 43 of the Museum of Natural History, United States National Museum, Washington, D. C., at 8:15 P.M. We are always happy to have visitors.

Our main project every year is the award of a $250 scholarship to a graduate student of Marine Biology. Our annual Spring Shell Auction produces the funds for the scholarships. All shells auctioned are gifts to the club and the proceeds are used for no other purpose. The auctions are a lot of fun and every successful bidder has the double satisfaction of getting nice shells as well as contributing to the education of a worthy student. Since there was no applicant the previous year, we awarded two $250 scholarships in the fall of 1967.

The principal speakers and their subjects during the year were: Dr. Alan J. Kohn, University of Washington, "Conus Faces Life"; Mr. Paul Chanley and his colleague Mr. Castagna, both of the Virginia Institute of Marine Science, "Collecting Live Pelecypoda" and "Larval Development"; Mrs. Jean Cate's Shellecture "Batanga Bonanza"; a beautiful film of Australia's Great Barrier Reef; Captain Carl I. Aslakson, "Photomicrographs of Small Shells"; Dr. Harald A. Rehder, Division of Mollusks, U. S. National Museum, "Shell Collecting in the Marquesas and Tuomotu Islands," a study and collecting trip aboard the cruiser "Pele"; Dr. R. Tucker Abbott, of the Philadelphia Academy of Science, "Curator's Choice"—the fifty shells he would most like to collect alive (this followed our annual dinner meeting in April); and Dr. Joseph Rosewater, Division of Mollusks, U. S. National Museum, showed some slides and told us about his recent visit to several European Museum shell collections in connection with his forthcoming monograph on Littorinidae for Indo-Pacific Mollusca.

Throughout our 1967–68 season we had a 5-minute talk by a member at each meeting. These mini-talks—all connected in some way with shells—were amusing, interesting, and educational. Another innovation was a 30 to 45 minute period before the beginning of each meeting for becoming better acquainted with each other, exchanging and identifying shells, and for looking at small displays of shells brought in by members. Sometimes these displays were related to the evening's program and sometimes they were just particularly large or beautiful or unusual in some way. These pre-meeting gatherings proved to be so interesting that it was sometimes a little hard to get the meetings started on time.

In addition to our annual scholarship award, we also are continuing to send the Indo-Pacific Mollusca series to the Seychelles Shell Club.

We welcomed 16 new members this year and we now have 65 members. If you are in Washington, D. C. on one of our meeting nights, we hope that you will visit with us.

NEW YORK SHELL CLUB, INC., Angela Savino, Rec. Sec'y.: New York Shell Club meetings are held at the American Museum of Natural History, at 2:00 P.M. on the second Sunday of the month, September through June. (Exceptions: the meetings in April and May will be held on the first Sunday.) As of June 1968 membership totaled 276: 194 regular and 82 corresponding, three life and one honorary member. Mr. and Mrs. Anthony D'Attilio were given life membership this year. Officers elected in June are: President, Milton Werner; Vice-President, Mart Hulswit; Treasurer, Mathilde Weingartner; Recording Secretary, Angela Savino; Corresponding Secretary, Grace McDougall. Mrs. Selma Feinberg is again serving as Librarian and Nick Katsaras as Historian. Dorothy Raeihle continues as editor of the "New York Shell Club Notes."

Guest speakers and club members making presentations this year were Hugh Porter—"Mollusks of North Carolina"; Dr. Kosuge—"Shells of Japan"; Albert and Ann Taxson—"Collecting in Portugal and Spain"; George Raeihle —"New York Marine Shells"; William Old—"Chitons"; Anthony D'Attilio— "Murex"; Neal Seamon—"Aruba, Bonaire and Curaçao."

The year's activities included a social meeting in place of the regular meeting in April. It featured a shell auction and buffet supper. The club's annual field trip was held on June 22nd at Long Beach Bay, Orient Beach State Park.

NORTH CAROLINA SHELL CLUB, Ruth S. Dixon, Secretary: "Tenth Anniversary; Tucker Abbott Speaks!" These headlines indicate that the club had a fabulous celebration of its tenth anniversary.

Officers are: President, Wade Gilles Brown; Vice-President, Hugh J. Porter; Treasurer, Elizabeth T. Mathews; Secretary, Ruth S. Dixon. Meetings are held four times each year—March, May, September and December: Fall and Summer at Atlantic Beach, Winter at the Museum of Natural History in Raleigh and Spring at Myrtle Beach, South Carolina. With over 225 members the club enjoyed one of its best years.

The Tenth Anniversary celebration was the highlight of the year. Members pooled their efforts during the past years in collecting North Carolina shells for the Museum. These were presented in honor of the late Mrs. Lulu Upchurch. It had been an ambition of the club to have Dr. Abbott as our guest speaker on this occasion, and to the delight of all he accepted our invitation and brought his favorite assistant, his wife, Sue. He gave an excellent illustrated talk on "Shells I Want Most to Find in my Lifetime."

The September meeting featured a report on the AMU Annual Conference in Ottawa, Canada—slides, photos, shells, stories of Expo '67, etc.

The Myrtle Beach meeting as always was a great success, with collecting excursions as well as several visits to Dick Petit's Shell and Book Store.

Dr. John Ferguson's workshop covered Carolina limpets and world Fissurellidae; these were illustrated by beautiful color slides taken by expert

photographer Dr. Jack Upchurch. Two movies shown were "Mollusks" and "Mysteries of the Deep."

The Diamond City ferry was chartered by the club for the summer field trip to Shackleford Banks across from Cape Lookout.

Guest speakers through the past year in addition to Dr. Abbott was our President, Mr. Wade G. Brown, who spoke on "Shelling Experiences in South America," Captain Josiah Bailey's "Early History of Shackleford Banks," and Dr. A. F. Chestnut who told us of "Molluscan Research of Dr. Robert E. Coker."

Finally, as this report is being written, about a dozen North Carolina Shell Club members are heading for the AMU meeting in Corpus Christi, Texas. We consider it an honor to be associated with the AMU. Although Texas is too far away for some of us, we look forward to seeing all of you—somewhere—next summer. In the meantime, have a good meeting in Texas.

THE NORTHERN CALIFORNIA MALACOZOOLOGICAL CLUB: The club has had a very interesting and active year. We held our second shell show in October; it was very successful and we are looking forward to our third.

A wonderful Christmas party was a double occasion as we also toasted the birthday of our President. Other monthly meetings provided a variety of interesting and informative presentations, among them "Chitons" by Allyn Smith who employed slides as did most of the other featured speakers: "Florida Snails and Their Egg Cases," Mary D'Auito; "Shell Collecting in the Pacific Northwest," Salle Crittenden; "Shells of Guam," Mr. and Mrs. Manuel Manalisay.

Other events were open houses, field trips and auctions. At the annual elections the following officers were chosen: President, John Saxby; Vice-President, Laura Burghardt; Recording Secretary, William Keeler; Corresponding Secretary, Muiriel Herring; Treasurer, Matie Wiard; Membership Chairman, Winogene Goodwin; Director at Large, Hiriam Goodwin.

Meetings are held the first Tuesday of each month (except July) in the Life Sciences Building, Room 4005, University of California in Berkeley.

PALM BEACH COUNTY SHELL CLUB, INC., John Root, President: Good field trips, programs, plus a shell show that was a resounding success, highlighted 1967–68 for the Palm Beach County Shell Club members. Fort Myers to the Keys, gallivanting around the southern part of Florida for shells, talks on Mexico, Grand Cayman and *Liguus*, provocative SEAFARI articles and study groups were samples of opportunities to shell and to learn about shells.

Came February and all attendance records were broken as the club held the ninth annual shell show at the Science Museum and Planetarium at West Palm Beach. Winner of the trophy presented by the Academy of Natural Science, Philadelphia was Corinne E. Edwards for her educational display of *Busycon contrarium*. Margaret Teskey and Muriel Hunter were the judges.

Officers for 1967–68 were John Root, President; William Ross, Vice-President; Lily Roberts, Recording Secretary; Margaret Kennedy, Corresponding Secretary; W. W. Mills, Treasurer; Cynthia Plockelman, Editor, SEAFARI.

PITTSBURGH SHELL CLUB, June Snyder, Corresponding Secretary: Visitors are welcome to attend our meetings, which are held the first Saturday of the month, November through June, at 2:00 P.M. at Mellon Bank, Fifth Avenue and Craig Street, Pittsburgh, Pa. The first meeting of the season, in October, is held in the home of one of the members. We have two field trips a year for collecting land, fresh-water, and fossil specimens. These are held in the spring and fall.

We were honored to have Dr. David Stansbery of the Natural History Museum of Columbus, Ohio, as the guest speaker for our third anniversary meeting in March. His talk on "Fresh-water Malacology—the Naiads and River Snails" was illustrated with colored slides and followed by a question and answer period. At this meeting our annual Shell Club Bulletin, edited by Gladys McCallum, was distributed. Other programs included "Shelling on Sanibel Island," Karen Vander Ven; "A Collecting Trip to the Upper Amazon," Dr. Neil Richmond; "Above and Below in the Caribbean," Norman Franke; "Ancient Seas in Allegheny County," Dr. C. J. Durden; "Shell Craft," Edith Luehm and Hyacinth Rowe, and "Shell Stamps," Dr. Juan J. Parodiz; a sound film "Rendezvous in the Reef"; and a panel discussion on exchanging shell parcels with people from other countries, by Bonnie Oatis, Gertrude Dietrich, Gladys McCallum and June Snyder.

Some of the other features were the annual Christmas shell sale, the second shell show, and a guided tour of the Invertebrate Section of the Carnegie Museum by Dr. Juan J. Parodiz.

Current officers: President, Mrs. Gladys McCallum; Vice-President, Mr. Norman Franke; Secretary of Records, Miss Sharon Snyder; Secretary of Correspondence, Mrs. June Snyder; Treasurer, Mrs. Esther Parodiz; Librarians, Mrs. Ruth Franke and Mrs. Jennie Lencher; Historian, Mrs. Karen Vander Ven; Conchological Reporter, Mrs. Ruth Franke; Councillor, Dr. Juan J. Parodiz.

ROCHESTER SHELL AND SHORE CLUB, Mrs. Doris Barton, Corresponding Secretary: Our meetings are held on the fourth Wednesday of each month from September through June—combining the November and December meetings as our annual Christmas banquet. We meet at 8:00 P.M. at the Charlotte Branch of the Rochester Public Library, 3612 Lake Ave., Rochester, N. Y., and all interested adults are cordially invited to attend. We'd love to see you as a visitor when you are in our city!

Our annual June shell auction and sale provided a tidy sum to add to our bank account to purchase additional books for our growing club library, and to further our club's aim of encouraging the study of Malacology and Conchology. Our new season began full speed ahead with a two-month, July and August, exhibit in the Main Hall of the Rochester Museum of Arts and Sciences. Included were displays of World-Wide Shells, *Spondylus americanus,* World-Wide Cones, a case showing the growth of mollusks, artifacts made from shell, and sea and shore animals related to the habitat of mollusks. There were eleven cases in all.

Two important beginnings marked our fifth year as the Rochester Shell and Shore Club. President, Mrs. Bee Plummer, was instrumental in starting

the Rochester Junior Shell Club for the younger set of shell collectors in the city. She has been ably assisted by Mr. Robert Lawson, president of the Junior Club. They meet twice a month on Saturday mornings, and are justly proud of their numbers.

This was also the first season for our new club publication, ROCHESTER SHELL NOTES AND QUOTES, edited and published by Mrs. James Barton. Notes and Quotes is mailed monthly to members with club notices, news of members, information exchanges, and articles of a more technical vein by our club advisors. We are currently having a contest for a cover design to be used in the coming year. Members were also privileged to be able to purchase Bahamian silver dollars, one side of which depicts a *Strombus gigas*, for keepsakes.

Our monthly programs were varied and all extremely interesting. September brought us Mrs. Hilda Peters from the Conchological Section, Buffalo Society of Natural Sciences, who thrilled us all with her talk and exhibit on "Miniature Shells." In October, Mrs. Mabelle Quine, one of our members, gave us a top-notch review on "Lady with a Spear." The Christmas banquet was a thorough success—good food, good fellowship, and Mrs. Marge Brenneman took us with her on a camera tour of her recent trip in Egypt. 1968 was here and in January Bee Plummer captivated our imaginations with her interesting presentation of her personal collection of Corals. February Mr. Bob Lawson took us down the Florida paths of "Tracking Mollusks." Color-sound movies were on the schedule for March. And in April, Mr. W. Stephen Thomas, Director of the Rochester Museum of Arts and Sciences, gave a lecture about "Andrew Garret, Hawaii's Pioneer Naturalist of the Sea." Member Dr. Eugene Wightman again brought special honors to our club by winning many blue and red ribbons in the Sanibel, Ft. Myers, and Naples, Florida, shell shows.

We were fortunate to again have the opportunity of visiting the personal Hobby Museum of Mrs. Homer Strong, one of our members, and to see her fabulous collections of dolls, jade, and shells. Also the shell doll house—made entirely of seashells! A group of us made the trip to the Buffalo Museum of Science in May to view the shells in the storage cabinets of the Conchological Section.

In this inland city of Rochester, we consider ourselves fortunate to list 42 active resident members and 14 non-resident members.

As we go into a new year, we have mixed feelings—our beloved president of the past five years, Mrs. Bee Plummer, is retiring from office—though we certainly hope not as an active collaborator with our new officers! It was through her initial efforts that Rochester Shell and Shore Club came into being, and through her continuing enthusiasm and work that it has continued and grown to be a club we can all be proud of.

Officers elected for the year 1968–69 are: President, Mr. James Barton; Vice-President, Mrs. Karl Abendroth; Treasurer, Mr. Karl Abendroth; Recording Secretary, Mr. Melvin Meyer; Corresponding Secretary, Mrs. James Barton.

ST. PETERSBURG SHELL CLUB, Florence Kuczynski, Corresponding Secretary: Our 1967–1968 meetings were again held on the second and fourth

Friday of the month from October to April, at the Florida Presbyterian College. Our members are a congenial group with an avid interest in all types of shell collecting and we welcome guests and new members with similar interests. We usually have a short business meeting and an entertaining or informative session. Our program subjects ran the gamut from member participation exchanges of shelling experiences to such technical discussions as "Shell Formation, Regeneration, etc.," "Cerithidae and Related Families" and "Cone Shells of West America"; to travelogues as "Shelling in the Pirates' Den" and "Camp with Us"; to popular interest shows like "Treasures of the Seven Seas" and "Shelling Adventures." All the above presentations were by our own members and were augmented with colored slides or other visual aids. The Shell Club is justly proud of the versatility of its representatives.

The activities of the past season included eight well-attended field trips to five nearby shelling locations; the donation of forty-two educational collections of Florida shells to schools throughout the United States and Canada, and our very successful shell show. Our social activities consisted of a Christmas Party and Shell Exchange, a picnic, a museum party and a half hour social break at almost every meeting.

The twenty-first Annual Shell Show was held February 28 through March 3, 1968. The judges were Dr. William J. Clench, Mrs. Germaine Warmke, and Mrs. Norma Ward Brown. The coveted Smithsonian Award went to Mary and Flynn Ford for their exhibit "Who's Who of Shelldom" and the Shell of the Show Award went to Annabel Wetzel for a large, rare, black *Murex ambiguous.*

Officers and Committees for the new year are: President, Selma Lawson; Vice-President, Florence Kuczynski; Treasurer, William Reader; Recording Secretary, Dorothy Hanssler; Corresponding Secretary, Mina Slinn; Librarian, Patricia Torrence; Directors-at-Large, Kitti Westfall and Roger Dunn; Field Trip Leaders, Irma Sehner and Robert Lipe; and Educational Shells, Emma and Dorothy Hanssler.

THE SAN ANTONIO SHELL CLUB, Myra Taylor, President: The club was organized in 1955 by our founder and first President, Mrs. Laura Gilbert, and this year we have 4 honorary life members, 45 active, 17 junior, 31 corresponding and 7 institutional members.

A busy year has unfolded, with our first shell show and sale, field trips, traveling scientific exhibits to the city's high schools, fine programs, and the growing excitement of planning for and participating in the AMU meeting in Corpus Christi in July.

Our quarterly publication, "The Texas Shell News," continues to expand, and we cordially invite other clubs to exchange publications with us.

Visitors are always welcome at our meetings on the fourth Monday of each month, 7:30 P.M., in the Educational Building of Asbury Methodist Church, 4601 San Pedro, San Antonio.

Officers for 1967–68 are: President, Myra Taylor, 900 Burr Road, Apt. 1-G; Vice-President, Lucille Taylor, 102 East Hermosa; Secretary, Harold Murray, 247 Pinewood; Treasurer, Jean Bayne, 219 Rosemary; and Editor-in-Chief, Mrs. Laura Gilbert, 451 Hammond Ave.

SANIBEL-CAPTIVA SHELL CLUB, Maude Meyer: Club meetings are on the third Monday evening of each month; November through April, alternating between Sanibel and Captiva. Visitors are always welcomed. Over the past season we had excellent attendance and enjoyed the company of many members of other shell clubs.

In November Selma Lawson came from Pass-a-Grille with a fine slide lecture on Jamaica, "Shelling in the Pirate's Den" together with rare and fine shells. The Christmas party in December featured a shell gift exchange and Jean Cate's recorded and illustrated shell lecture entitled "Batangas Bonanza." This worked so well we tried three more: Roy Poorman's "Guaymas," Thelma Hartley's "Shelling around Australia's Coastline" and in March, "Rare Shells" by Jean Cate plus a rerun, by request, of a film on the Barrier Reef which ex-Ambassador William Stevenson of the Philippines had shown two years before. Also in March we had a bonus meeting when Jean and Crawford Cate (in person) gave us the second part of their Australian adventures. We found these shell lectures so satisfactory that we plan to use more this coming year. We have also lined up some nearby speakers. Housing on the islands during the height of the season presents problems for guest speakers.

Our conservation efforts continue. Instead of reprinting our booklet, we issued 50,000 vari-colored flyers—a reproduction of a poster we did for the Southern Florida Conservation meeting and which now hangs in the Chamber of Commerce at the Sanibel end of the Causeway. These are distributed through the Chamber of Commerce, motels and island shops. Perhaps before it is too late we shall be able to do something about the greedy people who take more mollusks than they can possibly use. We are also co-operating with the Conservation Foundation, Inc., an outgrowth of the J. N. "Ding" Darling Sanctuary. It will eventually encompass a number of areas on both islands and have a center for research graduate study, information and education.

The April meeting was as always a dinner party with the necessary reports and election of officers: President, Harvey G. Meyer; 1st Vice-President, Jasper DuBose; 2nd Vice-President, Mrs. J. C. McCaul; Recording Secretary, Mrs. Joe Dayton; Corresponding Secretary, Mrs. Donald Reese; Treasurer, Mrs. Gregory Flores.

THE SOUTHWEST FLORIDA CONCHOLOGIST SOCIETY, Marjorie Conniff, Treasurer and Corresponding Secretary: Our club was chartered in October, 1967 with 115 charter members. One month later our group numbered 140 and we now have 170 and a number of honorary members.

The club meetings have been very interesting under leadership of President Helen Denny. They include a short business meeting, a program by guest speaker, learning when, where and how to find shells, then how to clean and process them; slides of shells and artifacts; discussion of the evening's shell displays; reports on field trips by members; shells presented for identification; door prize drawings. Some club members enjoyed a trip to Bimini, where they collected 162 species.

Our first annual shell show was held during the Fort Myers Beach Shrimp Festival from February 24 to March 3. Held in the beautiful lobby of the Almaza Motel, the show featured exhibits of shells from our waters, from other well known Florida shelling areas and from all parts of the world. Judges

were Mr. William E. Old, Jr. from the American Museum of Natural History and Robert L. Wagner, editor of Van Nostrands Standard Catalog of Shells. 1834 visitors viewed 103 entries while 41 others had to be refused because of lack of space.

Current officers are: President, Helen Denny; Vice-President, Harold Gregory; Treasurer and Corresponding Secretary, Marjorie Conniff; Recording Secretary, Jeanne Walther; Hospitality Chairman, Ellen Wethington.

Meetings are held the second Tuesday of each month at 7:30 P.M. at the Lee County Electric Cooperative Building, North Fort Myers, Florida. A cordial invitation is extended to all visitors. A monthly Newsletter reporting membership activities and scientific information concerning shells is distributed to all present and mailed to members unable to attend. We maintain a lending library for members. Each new member receives a hearty welcome and a printed copy of "Happy Shelling, Cleaning your Treasures, and Univalves and Bivalves."

YUCAIPA SHELL CLUB, Arylene Baylies, Secretary: Current officers are: Robert Waller, President; Karl Lust, Vice-President; Howard Fletcher, Treasurer; Louis Mousley, Librarian; Lillian Miles, Historian; Arylene Baylies, Secretary; Bessie Falconer, Program Chairman. Meetings are held the third Sunday of each month except August, 2:00 P.M. at the Mousley Museum of Natural History in Yucaipa. July is the annual pot luck picnic and shell auction.

This year different members have taken turns putting their choice shells on exhibit, adding much interest to the meetings. Speakers have been outstanding, usually with slides or movies to illustrate the talks. One couple from Okinawa had shells for sale with unusually complete data. Our annual shell auction adds spice to the day and money to our treasury and the annual Christmas party and shell exchange puts finishing touches to each enjoyable year.

Special speakers and topics for 1968 were as follows: Mr. and Mrs. Ralph Hall, speaking on shell exchanging told of methods of making contact, mailing and some of the by-products of trading and personal satisfaction; Mr. E. R. Fisher, "One Man's Garden," with beautiful pictures; Mr. Don Cadien, a zoology student, "Nudibranchs and Related Shelless Animals"; Mr. Roy Poorman, "How to Take a Picture" illustrating the reverse lens method of taking close-ups of minute shells; and Miss Clara Blesener, traveler, photographer, lecturer and shell collector.

We are fortunate indeed to have as a member Dr. S. Stillman Berry, internationally famous, who was recently given the Grail Award for 1968 by the Redlands (California) Knights of the Round Table. The award was given for Dr. Berry's distinguished achievements in the field of science, and the personal influence he has had on the lives of scores of young men who have been inspired by his help and encouragement. Dr. Berry is also a nationally recognized iris fancier, while his shell collection is one of the most outstanding anywhere outside of a museum, and his remarkable library consists of many rare books.

Other AMU Shell Club Affiliates (see pages 96, 97 for complete listing and addresses):

Boston Malacological Club, Coastal Bend Shell Club, Conchological Club

of Southern California, Connecticut Shell Club, Fort Myers Shell Club, Fort Myers Beach Shell Club, Guam Shell Club, Gulf Coast Shell Club, Hawaiian Malacological Society, Lower Keys Shell Club, Oregon Shell Club, Panama Shell Club, Philadelphia Shell Club, Sacramento Valley Conchological Society, San Diego Shell Club, South Florida Shell Club, South Padre Island Shell Club.

IN MEMORIAM:

Henry Dodge

James B. Gross

William Marcus Ingram

Roy L. Morrison*

George M. Moore

Dr. and Mrs. John W. Parsons

V. D. P. Spicer*

Fred Tobleman*

William F. White

* Charter Member

ACTIVE MEMBERS

Membership List Revised December 1, 1968

* Pacific Division member

Abbott, Dr. and Mrs. R. Tucker, Dept. of Mollusks, The Academy of Natural Sciences of Philadelphia, 19th and The Parkway, Philadelphia, Penn. 19103.

*Adams, Elmo W., 747 Winchester Dr., Burlingame, Cal. 94010 (Feeding habits of Gastropoda.)

Adams, Lawson, 2100 S. Bay St., Milwaukee, Wisc. 53207. (Amateur.)

Aguayo, Dr. Carlos G., College of Agriculture, Mayagüez, Puerto Rico 00709.

Albert, Mrs. Ernest, 905 Bayshore Blvd., Safety Harbor, Fla. 33572

Aldrich, Dr. Frederick A., Marine Sciences Research Lab., Memorial Univ., St. Johns, Newfoundland, Canada. (Decapod cephalopods.)

Alexander, Robt. C., 423 Warwick Rd., Wynnewood, Penn. 19096.

Allen, Dr. J. Frances, 6000 42nd Ave., #311, Hyattsville, Md. 20781

Allen, Mr. and Mrs. Lawrence K., Box 822, Pt. Isabel, Texas 78578. (*Murex, Pecten*; world marine.)

Allen, Miss Letha S., 187 Argyle St., Yarmouth, Nova Scotia, Canada. (Mollusks in general.)

*Allison, Dr. Edwin C., 454 Ravina St., La Jolla, Cal. 92037 (Fossil, Recent & mego-micro marine invertebrates.)

Anders, Kirk W., Shells of the Seas, Inc., P.O. Box 68, Kissimmee, Fla. 32741 (Volutidae; all rare shells.)

Anderson, Carleton J., Kettle Creek Rd., Weston, Conn. 06880

*Arnold, Ben E., Rt. 5, Box 27, Port Orchard, Wash. 98366. (Tropical and semi-tropical marines.)

Arthur, John W., Nat. Water Quality Lab., 6201 Congdon Bldg., Duluth, Minn. 55804 (Water quality requirements of freshwater mollusks.)

Aslakson, Capt. and Mrs. Carl I., 5707 Wilson Lane, Bethesda, Md. 20034

Athearn, Herbert D., Rt. 5, Box 376, Cleveland, Tenn. 37311. (Freshwater mollusks.)

Athearn, Mrs. Roy C., 5105 N. Main St., Fall River, Mass. 02720. (Land shells.)

Auerbach, Stuart, 1710 Algonquin Trail, Maitland, Fla. 32751

*Avery, Mrs. Rada Gail, 1823 N. 40th St., Phoenix, Ariz. 85008. (Shells of N. America; exch.)

*Baily, Dr. Joshua L., P.O. Box 1891, La Jolla, Calif. 92038.

Bailey, S. Sgt. Brian A., 78th Finance Sect., APO New York, N.Y. 09046

Baker, Mrs. A. W., Box 715, Valdese, N. C. 28690

Baker, Dr. and Mrs. Horace B., 11 Chelten Rd., Havertown, Penn. 19083.

Baker, John A., P.O. Box 4524, Patrick AFB, Florida 32925 (General interest.)

*Baker, Nelson W., 279 Sherwood Dr., Santa Barbara, Calif. 93105. (General interest.)

Bark, Ann, 245 Winter St., Weston, Mass. 02193

Barlow, Alice Denison, 5 Downey Drive, Tenafly, N.J. 07670.

Baum, Newman N., 83 Weaving Lane, Wantagh, L. I., N. Y. 11793

Becker, Albert F., 2157 Sunrise Dr., La Crosse, Wis. 54602. (Mississippi River shells.)

Becker, Miss Louise W., 2 Lexington Ave., Buffalo, N. Y. 14222.

Bedell, Adele Koto, 2643 Laundale Dr., Beloit, Wisc. 53511.

Bedford, Charles A., Gen. Del., Roberts Creek, British Columbia, Canada.

Beetle, Mrs. Dorothy, Peninsular Junior Nature Museum, J. Clyde Morris Blvd., Newport News, Va. 23601 (Land and freshwater world shells).

Behrens, Grace, 222 Lenox Rd., Apt. 6-F, Brooklyn, N. Y. 11226. (Abalone; starfish.)
Bennett, Chas. G., 640 73rd St. Ocean, Marathon, Fla. 33050 (*Murex*.)
*Bequaert, Dr. Joseph C., Dept. of Entomology, Univ. of Ariz., Tucson, Ariz. 85717.
Berg, Mrs. Frederick C., Box 115, Georgetown, Md. 21930. (Shells of the Florida Keys.)
Berry, Dr. and Mrs. Elmer G., 1336 Bird Rd., Ann Arbor, Mich. 48103.
*Berry, Dr. S. Stillman, 1145 W. Highland Ave., Redlands, Calif. 92373.
Bickel, David, Dept. Geology, Ohio State Univ., 125 S. Oval Dr., Columbus, Ohio 43210. (Systematics and ecology of freshwater mollusca.)
Bijur, Jerome M., 135 7th Ave. N., Naples, Fla. 33940. (Buy, exch. Florida marine.)
Bippus, Mr. and Mrs. Alvin C., 2743 Sagamore Rd., Toledo, Ohio 43606. (Marine gastropods.)
Blaine, Mr. and Mrs. Alger P., 237 19th Ave. S., St. Petersburg, Fla. 33705 (Summer: 74 Palmer Ave., Springfield, Mass. 01108)
Bleich, Henry, P.O. Box 598, Dania, Fla. 33004.
Blinn, Dr. Walter C., Dept. Nat. Sci., Michigan State Univ., E. Lansing, Mich. 48823. (Ecology, behavior of land snails.)
*Bonus, Mrs. Warren, 26418 Marine View Dr., Kent, Wash. 98031 (All shells)
Boone, Mrs. Hollis Q., 3706 Rice Blvd., Houston, Texas 77005
Boss, Dr. Kenneth, Museum Comp. Zool., Cambridge, Mass. 02138
Bottimer, L. J., St. Francis Village, Crowley, Texas 76036 (Recent & fossil mollusks.)
Bowman, Mrs. G. A., 159 Nobel St., McMasterville, Quebec, Canada
Boyd, Dr. and Mrs. Eugene S., 295 Gillis Rd., Victor, N. Y. 14564. (Phylum Mollusca, all aspects.)
Bradfield, Mrs. Jesse, 339 Mt. Alto, Rome, Ga. 30163. (General interest.)
Bradley, J. Chester, 604 Highland Rd., Ithaca, N.Y. 14850.
Bradley, John C., 469 Farmington Ave., Waterbury, Conn. 06710. (Travel and collect.)
Branson, Branley A., P.O. Box 50, Eastern Ky. Univ., Richmond, Ky. 40475
*Bratcher, Twila L., 8121 Mulholland Terr., Hollywood, Calif. 90046.
Brooks, Mr. and Mrs. John C., 3050 Sunrise Blvd., Ft. Pierce, Fla. 33450
*Brown, Dorothy, 2535 Loring St., Pacific Beach, San Diego, Calif. 92109. (Pectens.)
Brown, Dr. and Mrs. Harvey E., 9455 S. W. 81st Ave., Miami, Fla. 33156.
Brown, Wade G., 1317 Arnette Ave., Durham, N. C. 27707
Brown, Mrs. Ward, 1420 N. Lakeside Dr., Lake Worth, Fla. 33460.
Broyles, Dr. and Mrs. Ralph E., 5701 Fairfield Dr., Ft. Wayne, Ind. 46807.
*Brunson, Dr. Royal Bruce, Montana State Univ., Missoula, Mont. 59801
*Bryan, Edwin H., Jr., Bishop Museum, Honolulu, Hawaii 96819. (Pacific biogeography and bibliography.)
Bullis, Harvey, Jr., Bureau Comm. Fisheries, Pascagoula, Miss. 39567.
Burch, Dr. John B., Museum of Zool., Univ. of Mich., Ann Arbor, Mich. 48104. (Land and freshwater mollusks.)
**Burch, Mr. and Mrs. John Q., 1300 Mayfield Rd., Apt. 61-L, Seal Beach, Calif. 90740
**Burch, Dr. and Mrs. Thos., 914 W. Palm Lane, Phoenix, Ariz. 85007. (Dredging.)
Bureau of Commercial Fisheries, Biological Laboratory, Oxford, Md. 21654
*Burfiend, John M., 236 S. Electric Ave., Alhambra, Cal. 91801
Burgers, Dr. and Mrs. J. M., 4622 Knox Rd., Apt. 7, College Park, Md. 20740.
**Burghardt, Mr. and Mrs. Glenn, 14453 Nassau Road, San Leandro, Cal. 94557

Burke, Alice L. and Thos. D., Jr., 1820 S. Austin Blvd., Cicero, Ill. 60650. (Marine mollusks of eastern U. S. A.)

*Campbell, Dr. G. Bruce, 11221 Elm St., Lynwood, Calif. 90268. (Typhiinae, Terebridae, E. Pacific.)

*Campbell, R. W., 5536 Hardwick St., Burnaby 2, British Columbia, Canada. (Pacific Coast marine and terrestrial gastropods; exch.)

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Casa Ybel Hotel and Beach Club, Sanibel Is., Fla. 33957.

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Conde, Vincent, Redpath Museum, McGill Univ., Montreal, Quebec, Canada.

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May, Elizabeth, 113 E. 60th St., New York, N. Y. 10022. (Mollusks of Great Barrier Reef, Fla. and W. Indies.)

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*SACRAMENTO VALLEY CONCHOLOGICAL SOCIETY, c/o Herbert W. Finke, 347 40th St., Sacramento, Calif. 95819.

ST. PETERSBURG SHELL CLUB, Mina Slinn, 7570 46th Ave., N., Lot 410, St. Petersburg, Fla. 33709

SAN ANTONIO SHELL CLUB, Mrs. Louis N. Goethel, 9402 Nona Key Dr., San Antonio, Texas 78217

*SAN DIEGO SHELL CLUB, San Diego Museum of Nat. Hist., P.O. Box 1390, San Diego, Calif. 92112.

SANIBEL-CAPTIVA SHELL CLUB, c/o Mrs. Harvey Meyer, Box 2342, Captiva, Fla. 33957.

SOUTH FLORIDA SHELL CLUB, Museum of Science and Nat. Hist., 3280 S. Miami Ave., Miami, Fla. 33129.

SOUTHWEST FLORIDA CONCHOLOGIST SOCIETY, c/o Helen Denny, Sanibel, Fla. 33957.

SOUTH PADRE ISLAND SHELL CLUB, P.O. Box 2110, South Padre Island, Texas 78578.

THE AMERICAN MALACOLOGICAL UNION, INC.

The American Malacological Union, Inc.
Pacific Division

ANNUAL REPORTS for 1969

AMU, Thirty-Fifth Annual Meeting

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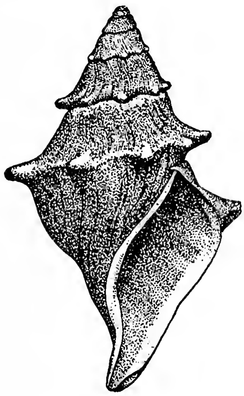

AMU, Thirty-Fifth Annual Meeting

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Bulletin number 36, December 1, 1969. Issued Annually by the American Malacological Union, Inc. Editorial Board: Morris K. Jacobson, Editor, Margaret C. Teskey, Secretary. Office of Publication: Route 2, Box 318, Marinette, Wisconsin 541143.

Mailed December 19, 1969

AMERICAN MALACOLOGICAL UNION
THIRTY-FIFTH ANNUAL MEETING

Marinette, Wisconsin — July 21–23, 1969

The thirty-fifth annual meeting of the American Malacological Union scored some remarkable firsts. It was the first such meeting in Wisconsin, and by happy coincidence early arrivals watched, via television, the first landing of man upon the moon.

The meeting was called to order on Monday, July 21st, 1969 in the beautiful new auditorium of the University of Wisconsin-Green Bay, Marinette Extension. President Joseph Rosewater during the four day period introduced forty-eight papers to 112 AMU members and their guests. The traditional features were enjoyed—Shell Club Night, the annual dinner at an area supper club, Friday's field trip to the Menominee River and an isolated small lake.

Another first for the 35th annual meeting—the first complete (or as complete as will ever be assembled) collection of Cypraeidae was put on display. It was due to the zeal of Alice and Tom Burke of the Chicago Shell Club who recruited specimens first from their own sizable collection, from their fellow club members, then from any collector about the country who would consent to loan the rarest of the family for this good cause, and to Jean and Crawford Cate who brought treasured specimens, then helped to set up the display in a tiered case in the University Administration Building. When again may malacologists expect to look at one time upon *Cypraea fultoni* (Crawford Cate), *C. teulerei* (Stan Dvorak), *C. guttata* (the Cates), *C. rabaulensis* (Ray Summers), *Lyncina broderipi* (American Museum of Natural History), *Zoila rosselli* (Dvorak)?

Also on display throughout the meeting were a dozen specimens of *Spondylus americanus,* unique in that they had been among hundreds which grew on the steel hull of an experimental Navy ship, sunk for a period of three years (1961–64) at 165′ off Key West, Florida. A witness reported that as the salvaged vessel broke water the encrusting shells made her resemble a flower garden. The twelve specimens were awarded as door prizes at the annual dinner.

Shell Club Night directed by Mr. Al Lindar, President of the Chicago Shell Club, gave delegates from the various clubs about the country a chance to report on the past year's activities of their groups. These ranged through shell shows, publications, instruction of school children, identification and collection forums, conservation. "Captain" Wheel of Syracuse, New York told of his continuing work for the Boys Club of his city, stressing his ever-present need of surplus marine items in any category. Highlight of the evening was one of Jean Cate's matchless Shellectures.

"Marinette, Wisconsin, a small town in the extreme northeastern corner of the state, is remarkable for having more churches and more licensed taverns than any town of like population in the world—Believe it or Not!"

So wrote Robert Ripley in the 1930s. Today's Ripley would have added,

"and more good restaurants." But AMU visitors had little opportunity to sample some of the culinary specialties of the region—pasties, for instance. These meat and potato pies, designed to be eaten from the hand, were introduced by Cornishmen who worked in the up-county iron mines a hundred years ago; today pasties may be purchased as frozen food in area supermarkets. Church suppers in the Belgian colony at the south end of Green Bay often feature chicken boo-yah, a thick and delicious stew, while fish boils are becoming popular at other community affairs—lake trout steamed on a bed of vegetables.

But none of these appeared at the annual dinner which was roast beef, family style. Following the cocktail hour places were taken in a charming private dining room where beside each plate was a small collection of colorful freshwater shells in a lucite box bearing the date and the AMU emblem.

The meal concluded, Dr. Rosewater introduced those at the head table, then the Past Presidents in reverse order of their dates in office, ending with Dr. William J. Clench (1935) who was to be speaker of the evening.

Dr. Clench's topic, Distribution of the Freshwater Mollusks of North America, was especially appropriate since the county in which Marinette is located lies in the drainage area of two of the largest of the Great Lakes, each with distinctive as well as overlapping faunas.

As he concluded President Rosewater performed his final official act in introducing his successor, Dr. Alan Solem. President Solem in a brief acceptance speech urged his listeners to attend next year's Key West meeting.

Although many departed on Friday morning for home or interrupted vacations, 44 collectors with gear ranging from hand sieves to SCUBA attire boarded a bus which took them to some of the cleanest water most had ever explored. The Menominee River is bordered by woodlands and isolated farms and for ninety miles upstream free of industrial pollution. An hour was all too short, but the second stop at tiny Lake Mary-and-Julia provided an entirely different fauna, including the slender lymnaeid *Acella haldemani*. Harold Walter's matchless drawings of this species had adorned the program cover, so search for it was diligent and, in a few cases, rewarded.

The American Malacological Union enjoys a rapport unique among such scientific societies, and with the generous help of the University staff, the gracious welcome of the townspeople together with the manifest appreciation of the delegates themselves, this was declared one of the finest annual meetings the organization has ever held.

MINUTES (CONDENSED) OF THE 1969 ANNUAL BUSINESS MEETING

The Executive Council had met on Tuesday evening and the following items of transacted business were reported to open the annual business meeting on July 24, 1969:

Annual reports of the Secretary and of the Treasurer (pages 4 and 5) were heard and approved;

A twelve page memorandum prepared by Dr. Albert Mead and his committee relating to improvement of east-west relationship was discussed and an action committee appointed to make further study;

Results of the mail ballot on the question of raising annual dues one dollar per member showed 138 in favor, 6 against; results were certified by the Council and the increase declared to be in effect;

Replies to the questionnaire circulated together with 1969 meeting notices were discussed and will be given consideration by the action committee;

A committee was appointed to formulate AMU policies on the subject of conservation;

The matter of increasing or decreasing the size and general interest of the Annual Report Bulletin was discussed and the Publications Editor was given carte blanche to act as he shall see fit;

It was decided to issue a Newsletter to be mailed to all AMU members in the Spring;

Discussion of the so-called 50 year rule terminated with a vote; results were ten to three in favor of suspension;

An invitation to hold the 1970 meeting in Key West, Florida was accepted;

Report of the nominating committee was heard and the nominated slate received the unanimous endorsement of the Council;

Meeting adjourned.

Annual reports of the Secretary and Treasurer were read and approved as read.

Nominating Committee Chairman Aurèle LaRocque read the following slate of nominated officers:

President, Alan Solem;

Vice-president, David H. Stansbery;

2nd Vice-president, G. Bruce Campbell;

Secretary, Margaret C. Teskey;

Treasurer, Mrs. H. B. Baker;

Publications Editor, M. Karl Jacobson;

Councillors-at-Large, Dorothea Franzen, William E. Old, Jr., Dorothy Raeihle, Gale G. Sphon, Jr.

Motion was made and carried that the Secretary be instructed to cast a unanimous ballot for the slate as read.

Brief discussion followed a request for clarification of the aforementioned 50 year rule; no decision was reached, no action taken.

Meeting adjourned.

REPORT OF THE SECRETARY OF THE AMERICAN MALACOLOGICAL UNION FOR THE FISCAL YEAR 1968

July 1, 1969

Membership at the close of 1968 stood at 728, 26 fewer than at the end of the previous year. Over the twelve month period 97 new members were enrolled, 3 resigned, 7 died and 113 were dropped for delinquent dues.

Over 900 letters of inquiry were received, most answered with the usual packet of mimeographed material. Unless specifically requested or coming from someone with a museum or university address, no invitation to join the AMU was extended, this to ease the burden upon the Treasurer and Secretary of processing one year memberships.

The Secretary is willing, if permitted by the Council, to make effort to increase AMU membership by sending the prospectus to non-members who subscribe to Nautilus and to Malacologia, to staff and students of university biology departments, universities themselves, libraries, shell clubs, etc.

Another change in procedure will be instigated next year. To ease the burden of the Treasurer who is swamped by State and Federal reports due in early January, the membership bills will be enclosed with meeting notices instead of with the Annual Report Bulletin. No change in the fiscal year need be made. Members will be billed as always from January first but will receive such statements in March or April.

675 copies of the 1968 Annual Report Bulletin were printed and mailed for $1890.49, a per copy cost of $2.80. With annual dues at $3.00 it is not necessary to consult the annual report of the Treasurer to ascertain that the AMU is in truth a non-profit organization.

1000 copies of How to Collect Shells were reprinted in 1968 at a per copy cost of .72¢. 1968 receipts for copies sold, $384.

Respectfully submitted,
Margaret C. Teskey, Secretary
AMERICAN MALACOLOGICAL UNION, INC.

Report of the Treasurer for the Fiscal Year ended Dec. 31, 1968.

Checking Account:		
Balance January 1, 1968		**$ 412.74**
Receipts:		
Regular and Family Members	**$1643.75**	
Corresponding Members	**71.50**	
Shell Clubs	**210.00**	
Sales—How to Collect Shells	**350.28**	
1968 Meeting at Corpus Christi	**767.21**	
Interest on Bonds—$3000 Girard Trust	**176.05**	
(Int. on Savings added directly to account—35.65)		
Sale back numbers of Bulletin	**21.00**	
Collection costs received	**1.25**	

Life Membership	60.00		
From authors for printing 1968 bull.	109.00		
Pacific Division Assessment	29.30		
Total General Receipts	3439.34		
Savings bond cashed	1000.00		
Withdrawal from Savings acc't	100.00		
Total deposits to checking account			4539.34
Total cash to be accounted for			4952.08
Disbursements:			
Printing & Mailing 1968 Bulletin	1975.09		
Other Postage	127.22		
Other Printing & Stationery	158.19		
Reprinting & Exp. chgs.-HTCS	721.12		
Adv't for HTCS	6.39		
Secretarial chg.-Corpus Christi meetg.	49.94		
AMU Sec's exp.-C.C. meeting	282.33		
Pac. Div. Sec's expense to P.D.	76.30		
Advance for C.C. meeting	25.00		
AAAS membership	10.00		
Telephone-Nominating, Publ., Sec., etc.	14.23		
Bank Charges	36.33		
Miscellaneous Expenses	33.21		
Pacific Assess. transferred	29.30		
Total Disbursements			3544.65
Checking account Balance, Dec. 31, 1968			1407.43
Total cash accounted for			4952.08
Savings Account Transactions, 1968			
Balance, Jan. 1, 1968	698.80		
Interest added	35.65	734.45	
Withdrawal to Checking Acc't		100.00	
Balance, Dec. 31, 1968			634.45
5% Savings Bonds, Jan. 1	4000.00		
one $1000 bond cashed & dep. in chking account	1000.00		
Savings Bonds, Dec. 31			3000.00
Recapitulation of Assets:			
Checking Account	1407.43		
Petty Cash, Secretary	100.00		
Petty Cash, Treasurer	10.00		
5% Savings Bonds, 3 $1000 Girard Trust Bank	3000.00		
4½ Savings Account, Colo. Federal Savings & Loan	634.45		
TOTAL ASSETS			5151.88

Liabilities:			
Life Membership Fund, 1967		1410.88	
Added 1968		60.00	1470.88
Unallocated Capital Fund *Net Worth*			3681.00
Net Loss for 1968	$129.66	(Offset by inventory of HTCS)	

Respectfully submitted,
Bernadine B. Baker, Treasurer

ABSTRACTS AND SUMMARIES OF PAPERS PRESENTED AT THE THIRTY-FIFTH AMU MEETING

SOME ALGAE ISOLATED FROM *HELISOMA TRIVOLVIS* (SAY)

RICHARD L. REEDER AND ROBERT G. ANDERSON
Department of Biology, University of Missouri-Kansas City, Missouri

Algae have been reported to be a source of food for some snails and living algae have been observed in fecal pellets. Our work reports the isolation and cultivation of algae from the shell, intestinal tract, and fecal pellets of *Helisoma trivolvis* (Say).

Snails were collected from the spillway of Lake Jacomo, an artificial reservoir in Jackson County, Missouri, and were kindly identified by Dr. Charles D. Miles, Associate Professor of Zoology, University of Missouri-Kansas City. Thirty specimens were returned to the laboratory in lake water, rinsed with sterile Bristol's solution (Nichols and Bold, 1965), pH 7.0, and then placed in a two liter jar containing 1.5 liters of this solution. No substratum was added to the container, nor was any foodstuff offered to the snails. A large size petri-plate lid was used to cover the container. The medium was changed 2–4 times daily during the course of the 9 week experiment. At each medium change the inside walls and bottom of the container were vigorously scrubbed in order to remove any organisms which might have settled during the intervening hours. At no time during the course of the experiment was there visible evidence of organisms within the medium or on the walls of the container.

The snails were active in this medium, moving vigorously over the walls of the container. Approximately two times daily it was noted that the fresh medium seemed to stimulate the snails to excrete fecal pellets. When this occurred, another medium change was undertaken. Some fecal pellets were examined microscopically while others were placed on agar plates in order to determine the species of algae present.

Determinations of algal species also were made from the shell surface and from the intestinal tract. Freshly collected snails, rinsed several times in Bristol's medium were held by forceps, and the shell was carefully dragged over the surface of a Bristol's agar petri plate. Algae were isolated from the intestinal tract without contamination from the shell or body surface by placing the snails into boiling water for 3 seconds, and then into 70% alcohol for 3 seconds. After rinsing the snails in distilled water, the shell was removed and the snail body was crushed and immediately placed on an agar plate.

The vivarium and algal cultures were maintained in a programmed Percival plant growth chamber. The following algae were identified: Green Algae: *Chlamydomonas globosa, Chlorella vulgaris, Coelastrum microsporum, Cosmarium turpinii, Dimorphococcus lunatus, Pediastrum Boryanum, Scenedesmus abundans* var. *spicatus, S. acuminatus, S. bijuga, S. opoliensis, S. quadricauda, Stigeoclonium nanum.* Blue-green Algae: *Oscillatoria Agardhii, O. limnetica.* Diatoms: *Frustulia asymmetrica.*

As seen from the above list, the green algae are the predominant organisms, only one species of diatom being present. These algae were found in

fecal pellets excreted from freshly collected snails and/or in the intestinal tract. The most abundant alga found was *Scenedesmus,* least common were *Cosmarium* and *Pediastrum,* which were observed only once. The fact that these algae could be isolated from fecal pellets does not suggest that some populations of these algae were not partially or wholly digested.

Certain algae were never found in fecal pellets. *Chlamydomonas globosa, Oscillatoria Agardhii,* and *Oscillatoria limnetica* were isolated from the shell and from the crushed viscera, but significantly were never found in fecal pellets, which would seem to indicate that the members of these genera were thoroughly digested in passage through the intestinal tract.

The snails survived well in Bristol's algal medium until the latter part of the seventh week. At this time we observed the first dead snail, which upon examination was noted to have corrosion on the shell. Probably this corrosion was due to abrasive action of grazing snails in quest of lime rather than to pH of the solution. The snails' shells at this time had been grazed free of any surface algae. Thus, as suggested by the low mortality rate of the snails, Bristol's medium appears to provide an environment that is near optimal.

Carriker (1946) and Bovbjerg (1965) showed that 5 days of starvation cleared the alimentary tract of fecal strands. In contrast, the snails in our experiment continued to excrete fecal pellets throughout the 9 week trial, though they were not fed. At no time were there any visible algal organisms in the vivarium, this due to the multiple daily changing of the Bristol's solution. Fecal pellets, however, maintained high populations of algae throughout the experiment. We doubt that sufficient algae were present on the shell surface to provide adequate food for the grazing snails, and we therefore suggest the possibility that a symbiotic relationship may exist between the snails and the algae in the intestinal tract.

At the end of the ninth week no further changes of Bristol's medium were made. After 6 days the snails were alive and the solution was slightly green due to the growth of algae. By the eighth day the solution was heavily contaminated and all snails were dead. In an attempt to account for the death of the snails, the contaminated solution was sterile-filtered and fresh snails were placed into full strength filtered medium, into filtered medium diluted to half strength with Bristol's solution, and into Bristol's medium. None of the snails succumbed in any of these three media. It would appear that extracellular products of the algae were not directly involved in the death of the snails.

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THE AMERICAN MUSSEL INDUSTRY–ECONOMIC PERSPECTIVES AND ECOLOGICAL IMPLICATIONS.

John M. Bates, Eastern Michigan University, Ypsilanti, Michigan.

(no abstract submitted)

SOME PROBLEMS AND TECHNIQUES IN REARING BIVALVE LARVAE

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AND

ARTHUR CHRISTIAN JOHNSON
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Northeastern University

The successful rearing of bivalve larvae is a relatively recent accomplishment. The reasons are that bivalve eggs and larvae are small, the free swimming period relatively long, and for most of this period the larvae must be fed. The difficulty of handling such small larvae (early straight-hinge average 75–85μ in length), the lack of good algal cultures for feeding, and the frequent infestations of the cultures by bacteria and fungus were the major causes of failure. Much of the early work of developing algal cultures and controlling infestations was done by Loosanoff and his co-workers at the USBCF laboratory, Milford, Connecticut.

The ultimate objective of our interest in rearing boring and fouling bivalves is to understand the factors controlling the settlement and successful attachment or penetration of the larvae. As we wanted to study larvae in the field, an inexpensive 'traveling laboratory' was developed that could be easily packed, shipped and assembled in any laboratory no matter how small, so long as there was a seawater system and electricity. The system has proved worthwhile and economically feasible for working periods of 2½ to 3 months or more. The specialized equipment shipped for our first work in the tropics included: 1) 2 Fulflo Filter Assemblies (Model Fl 50–10) and a carton each of 1, 15 and 30μ replacement cartridges to remove particulate matter and biological contaminants from the water; 2) an ultra-violet water treatment unit obtained through the USBCF laboratory at Milford, Connecticut with 2 extra General Electric U-V germicidal light tubes (model G36T6) for controlling bacteria and fungus; 3) a set of stainless steel sieves with meshes ranging from 23 to 300μ for separating and washing the eggs and the larvae; 4) an abundance of glass, flexible tygon and gum rubber tubing; 5) a Marco air pump; 6) two 5 gal. glass carboys; 7) 4 each of 1000, 400 and 250 ml. beakers; 8) a quantity of disposable pipettes; 9) a Leitz Labolux-D microscope with standard base and pillar stand, an ultra pak illuminator, dipping cones and a Leica camera attachment with exposure meter. Dissecting microscopes were available at the laboratory. In place of an autoclave we used a large pressure cooker.

During this first working period we followed the general procedures for rearing larvae. The adults of all species were dissected from the wood so that we could identify the species and be sure of the source of the eggs and sperm. Ripe adults of oviparous species were placed in individual petri dishes until they spawned. The eggs were removed by pipetting, washed and placed in large beakers of fresh millipore filtered seawater and a small

suspension of sperm was added. When fertilization was completed the eggs were again washed to remove excess sperm and the dividing eggs were put in large carboys ¾ filled with sea water which had been passed through the 15 and 1μ filters and the U-V treatment unit. Air was bubbled through the culture and the water was changed every two days. We found, however, that the carboys were difficult to handle and that keeping all the larvae in one large container could result in the loss of the entire culture. Consequently we now keep our cultures in several 1 or 2 quart plastic refrigerator boxes, which are easier to handle, and an infestation in one subculture will not endanger the entire crop of larvae.

In our early experiments the pediveligers were held in beakers and small pieces of wood were suspended in the water. This procedure did not allow continuous observations of the larvae under the microscope and made repeated observations of the same specimen difficult. Changing the water and removing the wood for examination and photographing disturbed the larvae and reduced the number that penetrated the wood. To alleviate this, micro-aquaria were made by inserting the tip of a pipette through a small hole made near the rim of the bottom portion of a 20× 100 mm disposable plastic petri dish. The pipette was sealed in place with silicone cement and then connected with tygon tubing to the sea water system. A series of these were set in a shallow water table, and the flow of the water to each was controlled by a valve or clamp. The substrate glued in the bottom of the petri dish can vary with requirements of the larvae being observed. For wood borers we used discs of white pine 3–4 mm thick. This procedure allows larvae to settle on only one surface and they can be observed continuously as they explore and penetrate the wood. It eliminates the necessity of changing the water or feeding the developing young and, when the borers have grown to adults, they are easily removed for spawning. Increase in burrow length can be observed by placing a strong light below the petri dish, and, by placing the microscope on the pillar stand, using the ultrapak illuminator and dipping cones, it is possible to observe all of the cultures with a minimum of effort without disturbing the animals.

For the past year, through the kindness of Dr. N. W. Riser, we have had laboratory space at the Marine Science Institute of Northeastern University at Nahant, Massachusetts. The laboratory has a fine seawater system but, unlike the tropics, the temperature of the water drops to 0° to 2°C in the winter. Consequently, without a heating system it is impossible to breed even the local species during the winter, and the adults of tropical and temperate species cannot be maintained. A two stage heating system was designed and

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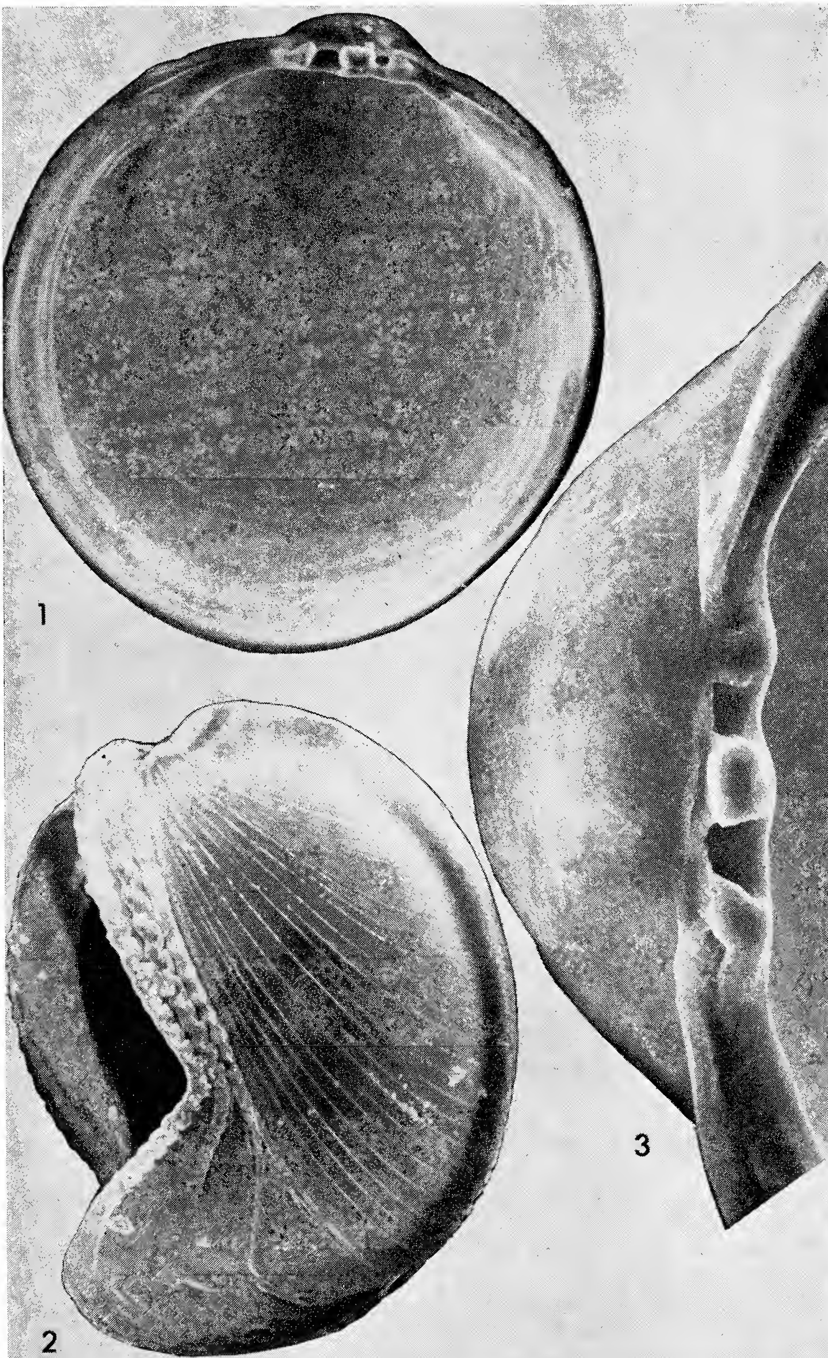
Plate 1 →

Young laboratory reared specimens of *Lyrodus pedicellatus* Quatrefages. Adult specimens from Alamitos Bay, California. Scanning electron microscope pictures show details of the hinge and sculpture impossible to obtain with the light microscope.

Fig. 1. Inner view of right valve of pediveliger (300×)

Fig. 2. Hinge line of same specimen (1100×).

Fig. 3. Side view of newly settled specimen showing sculpture of the larval shell and the beginning of the development of the adult shell (240×).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built in cooperation with Mr. Thomas Wait of Northeastern University. The water, after passing through three 120μ filters, enters a 54 cubic foot wooden, fiber glass lined tank set as high as possible so that the water is fed to the culture tanks by gravity. Here the temperature of the water is raised to 10° to 15°C by means of three 5,000 watt quartz heating units. Most of this water is used for work with temperate species or for maintaining summer conditions for northern species. It can be passed through 30, 15 and 1μ filters for work with larval cultures. Some of the water goes into a small plexiglass heating tank where the temperature is further raised by using 1 to 3 vycor 1000 watt immersion heaters, depending on the amount of increase needed to reach the desired temperature. This tank is usually maintained at 27°C and most of the water feeds into the tropical holding tank which is held at 27°C but can be raised to 30° to 34°C when inducing animals to spawn. It is mixed with 10° to 15°C water from the main tank to maintain the temperate water tank at 18° to 20°C. Except for the large heating tank the system at Nahant is portable and can easily be moved.

The purchase of a window air conditioner for the smallest room in the laboratory has allowed us to maintain algal cultures for feeding purposes. Stock cultures were obtained from Dr. Guillard of the Woods Hole Oceanographic Institute, and we follow his technique in maintaining them.

Problems of bacterial, fungal or ciliate infestations in the larval cultures are best controlled by employing good laboratory techniques. Frequent thorough washing of the eggs and larvae with 1μ filtered water drawn slowly through the U-V tube greatly reduces bacteria and virtually eliminates all other contaminants. All specimens, wood or otherwise, must be carefully cleaned on the outside as soon as they arrive at the laboratory in order to prevent contamination of the holding tanks.

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CABEZA DE VACA, DEALER IN SHELLS

James X. Corgan
Austin Peay State University, Clarksville, Tennessee

Abstract

Every American school child learns that Alvar Núñez Cabeza de Vaca led the first European exploration of the American Gulf Coast. Few people realize that Cabeza de Vaca was the first Caucasian merchant in the southwestern United States. Few conchologists realize that he was a dealer in shells. During the years 1530–1534 he operated out of the Galveston area and traded widely in the central Gulf Coast. About twenty-two months were spent in the "field," on extended business trips into the then unknown interior of the continent.

One result of Cabeza de Vaca's mercantile activities was an increased knowledge of American geography. Another result was the distribution of marine molluscan shells to localities in northern Texas, northern Louisiana, and perhaps southern Oklahoma. For at least five centuries before Cabeza de Vaca's time, marine shells had been used by inland aborigines. They are common in scores of archaeological sites and they pose a major problem in historical interpretation. How did thousands of marine shells reach the interior of the continent? Do pillage and occasional barter between tribes or individuals account for the movement of vast numbers of shells? Why do similarly carved marine shells occur at widely separated, but roughly contemporaneous, sites? Were there professional traders? Did the traveling salesman play a significant role in the aboriginal American economy?

Cabeza de Vaca, dealer in shells, provides us with the autobiography of one 16th Century American traveling salesman. It is a unique source of information on commerce in aboriginal America.

A detailed reconstruction of Cabeza de Vaca's trade is not possible. He was generally lost as he traveled and recorded his experiences years after his adventure ended. His literary style de-emphasized objective description and the species he traded in are unknown. In writing his memoirs, Cabeza de Vaca de-emphasized his mercantile career. It was lost time, it did not directly contribute to an escape to New Spain. Despite these severe limitations, translations of the original manuscripts (Bandelier, 1905; Smith, 1851) and scholarly interpretations (cited in Covey, 1961; Terrell, 1962) can be used to establish the chronologic and geographic limits of his trade. Writings

can also be examined for lists of trade goods, evidence of business competition, and buyer-seller relationships.

Cabeza de Vaca, a slave of coastal Indians, became a merchant when he convinced his masters that a merchant might bring peace. Raiding parties from the interior regularly pillaged the coast. They were drawn, at least in part, by a cultural need for shells. A neutral trade, an alien trader, obviated the need for war. Trade brought peace. Wherever he journeyed, Cabeza de Vaca was warmly received. Undoubtedly a fair skin and an alien appearance were great assets; still his customers had clear concepts of trade and experience in trade. Inland customers needed marine shells. Coastal peoples wanted ocre and other products of the interior.

In 4 short years his shell trade carried Cabeza de Vaca from abject slavery to honor and wealth. He became a celebrity and eventually a great medicine man. Other things came to overshadow the shell trade but the business itself was a commercial success. Cabeza de Vaca's manuscripts do not allude to competitors. His concept of a trader's role in commerce was apparently new to those who had held him slave. His commercial relationships suggest that he was the only trader. Apparently plunder and disorganized trade between individuals were the normal methods through which marine shells moved inland on the 16th century Gulf Coast.

It is unfortunate that Cabeza de Vaca was a 16th century shell dealer and that his base of operations was an economically deprived region where the cultural level was presumably low. Most archaeological sites that yield abundant shells predate the 16th century. They may have been supplied by direct or indirect contact with more advanced coastal peoples. Still, this is conjecture, and Cabeza de Vaca's recollections remain the only objective description of aboriginal commerce in the American southwest.

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SOME MOLLUSCA OF CEDAR BOG, CHAMPAIGN COUNTY, OHIO

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Cedar Bog is a nature sanctuary maintained by the Ohio Historical Society. It is located about five miles southwest of Urbana in Champaign County, Ohio. This sanctuary has been of great interest to the botanists for some time because within its boundaries is an arbor vitae or northern white cedar swamp, a bog meadow and a marl meadow. Each of these plant associations is more typical of northern Michigan, Wisconsin, and Canada.

The sanctuary is situated over 460 feet of glacial deposits from three, possibly four, glaciers. The last glacier, the Wisconsin, covered Champaign County about 19,000 years ago. When the Wisconsin glacier advanced, it

was partially slowed by a high point at Bellefontaine, about 25 miles north of the bog. This caused the ice to move into Champaign County in two lobes, the Miami and Scioto lobes.

When the glacier retreated from Champaign County, a large outwash plain was formed between the two lobes. This outwash is composed of sorted sands and gravels which allow ground water to pass through it and frequently to the surface. This whole outwash plain was an area of many springs and ponds. Many of these springs and ponds have since been eliminated by agriculture and artificial draining.

The ground water also passes through a lot of calcareous glacial till. The alkalinity due to the presence of calcium carbonate in the water and the constant water source itself has created conditions which allow the arbor vitae, the bog, and marl meadows to exist and be maintained far out of their present range. These conditions are also ideal for molluscs.

The soils in Cedar Bog are mainly organic in nature. Organic soils develop in previously ponded areas from plant remains. They vary greatly in depth and are usually underlain by marl, sand and gravel, or till. These soils occur on level to depressed relief and are very poorly drained. Charlisle muck and Tawas muck are both slightly acid to neutral. Tawas muck differs in having a little higher mineral content. The Abington silty clay loam is a mineral soil developed over a silt deposit which overlays sand and gravel. It is neutral and high in organic matter.

At the present time Cedar Bog can be divided into ten vegetation zones. This paper concerns some of the mollusca of three of these vegetation zones. The structure of the arbor vitae association is usually quite simple. In the young dense stands there are no other plants at all. As the cedar stands get older and more open, liverworts, mosses, and ferns move in. In many of the cedar stands a fairly well developed herbaceous level can be found with such plants as jack-in-the-pulpit, violets, partridge berry, and several species of orchids.

The leaf litter is usually moderately thin and often dry on the surface, but quite moist a few cm below the surface. The leaves of white cedar are small and sometimes the surface has a granular appearance when the leaflets break up.

The larger stands of cedar which lie along the edge of the stream frequently have springs and small pools which may have *Pomatiopsis lapidaria* (Say) around the edges and *Lymnaea humilis* Say, *Physa* sp., *Gyraulus parvus* (Say) and *Pisidium casertanum* (Poli) in them.

So far 28 species of mollusks have been recorded as living in various parts of the white cedar association; 23 species are terrestrial snails, four are aquatic snails and one sphaeriid. Of these, seven species are common, in that they were found living when most of the collections were made. These are, in order of their abundance; *Carychium exile* H. C. Lea, *Punctum minutissimum* (Lea), *Guppya sterkii* (Dall), *Striatura milium* (Morse), *Gastrocopta pentodon* (Say), *Vertigo milium* (Gould), *Columella edentula* (Draparnaud).

Several large land snails were found in the cedar, but usually under or in logs or at the edge. These are; *Mesodon thyroidus* (Say), *Anguispira alternata* (Say), *Zonitoides arboreus* (Say), *Succinea ovalis* Say, *Nesovitrea binneyana* (Morse).

In the bog meadow the water is usually below the surface, but there are many small pools or puddles of water and side streams. The soil is a mixture of marl and peat. There is a greater number of different plant species here than in any other zone in the swamp. This area is characterized by many sedges and grasses which form hummocks.

Shrubby cinquefoil, swamp birch, small arbor vitae, marsh ferns, marsh violets, fringed gentian, and many composites such as goldenrods, asters, and sunflowers are also abundant in the bog meadow.

Twenty-three species of mollusks have been found living in the bog meadow: 18 terrestrial snails and 5 acquatic snails. Of these, 8 are considered common. These are, in order of their abundance; *Carychium exiguum* (Say), *Succinea* sp., *Stenotrema leai* (Binney), *Gastrocopta tappaniana* (C. B. Adams), *Vertigo gouldi* (Binney), *Triodopsis multilineata* (Say), *Pomatiopsis lapidaria* (Say), *Lymnaea humilis* Say.

In the marl meadow the water is at or above the soil surface throughout the area. The plants which characterize this area are grasses, sedges, bladderwort, grass pinks, fringed gentian, and many asters and goldenrods. Many parts of the marl meadow are devoid of much vegetation and are quite open.

Sixteen species of snails have been found living in the marl meadow: 10 terrestrial snails and 5 aquatic snails and one sphaeriid. Again 8 species seem to be common; *Carychium exiguum* (Say), *Strobilops labyrinthica* (Say), *Succinea* sp., *Glyphyalinia indentata* (Say), *Stenotrema leai* (Binney), *Triodopsis multilineata* (Say), *Pomatiopsis lapidaria* (Say), *Lymnaea humilis* Say.

CHANGES IN THE NAIAD FAUNA OF THE CUMBERLAND RIVER AT CUMBERLAND FALLS IN EASTERN KENTUCKY

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The Cumberland River was first collected *at Cumberland Falls,* an 85′ high natural barrier, by Wilson and Clark (1914) in 1911. Their records are the best available concerning the original naiad fauna. Just prior to the closing of Wolf Creek dam, which produced Lake Cumberland just downstream, Neel and Allen (1964) collected this same site in 1947–1949. Changes during this 40 year span may be attributed to the mining and washing of coal above the falls.

A third collection was made at this site in 1961 in an effort to determine what changes had occurred following the impoundment of the river. It is purely a coincidence that this collection was made just 50 years after Wilson and Clark and that the same number of specimens, 810, were collected on both occasions.

The data of Wilson and Clark were converted from percentages into number of specimens where possible. The results from all three collections are presented in the table below. The apparent changes noted for each species are for the half-century period between 1911 and 1961.

Changes in faunal composition should *not* be due to any alteration in current nature of the substrate sediments, or modification of upstream barriers. Changes before 1947–1949 may be due to an increase in acids due

	Wilson & Clark		Neel & Allen	Stansbery		
	1911		1947–1949	1961		
Species Recorded	N	%	Relative Abundance	N	%	Change ?
Lasmigona costata (Raf., 1820).	41	5	0	1(?)	x	–
Tritogonia verrucosa (Raf., 1820).	32	4	a	75	9	+
Quadrula pustulosa (Lea, 1831).	49	6	a	122	15	+
Cyclonaias tuberculata (Raf., 1820).	x	x	0	0	0	o
Elliptio crassidens (Lam., 1819).	57	7	c	(2)	x	o
Elliptio dilatatus (Raf., 1820).	122	15	a	113	14	S
Ptychobranchus fasciolaris (Raf., 1820).	81	10	a	35	4	–
Ptychobranchus subtentum (Say, 1825).	x	x	0	0	0	o
Obliquaria reflexa Raf., 1820.	8	1	0	0	0	o
Actinonaias ligamentina (Lam., 1819).	194	24	a	39	5	–
Actinonaias pectorosa (Con., 1834).	73	9	a	161	20	+
Plagiola lineolata (Raf., 1820).	x	x	0	0	0	o
Truncilla truncata Raf., 1820.	16	2	r	0	0	o
Proptera alata (Say, 1817).	8	1	c	28	3	+
Medionidus conradicus (Lea, 1834).	x	x	a	154	19	+
Ligumia recta (Lam., 1819).	8	1	a	7	1	S
Villosa trabalis (Con., 1834).	41	5	a	7	1	–
Villosa iris nebulosa (Con., 1834).	0	0	r	27	3	A
Villosa lienosa (Con., 1834).	x	x	0	9	1	+
Lampsilis ovata f. *ovata* (Say, 1817).	49	6	0	10	1	–
Lampsilis ovata f. *ventricosa* (Bar., 1823).	0	0	a	0	0	–
Lampsilis fasciola Raf., 1820.	16	2	c	20	2	S
Total Species Recorded	20	—	15	16	—	
Total Specimens Collected	810	—	unknown	810	—	

N = number of specimens	a = abundant	A = added	= 1 species
% = percent of total	c = common	+ = increasing	= 6 species
x = species present	r = rare	S = stable	= 3 species
(2) = subfossil remains only	0 = none taken	– = decreasing	= 5 species
		o = extirpated	= 6 species
		Total	= 21 species

to coal operations upstream. These changes included the loss of 4 species and the gain of 1 species. Changes after 1949 may be due to the residual effects of coal operations added to the influence of impoundment downstream. These changes appear to include the loss of 2 species and changes in the status of most others.

This site is now bracketed by two obvious barriers, one natural and of long standing upstream, the other artificial and of recent origin just downstream. Observations on the naiad fauna of this and similar sites into the future may well reveal the effects of such barriers even though neither operates directly at the site itself.

CONTRIBUTION TO THE KNOWLEDGE OF NEW ENGLAND NUDIBRANCHS

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Abstract

Three species of nudibranchiate mollusks in the family Coryphellidae were studied throughout the year at the Marine Science Institute, Nahant, Massachusetts. Observations on foods, reproductive cycles and types of development are reported for *Coryphella verrucosa rufibranchialis* Johnston, *Coryphella stimpsoni* Verrill and *Coryphella salmonacea* Couthouy.

C. v. rufibranchialis occurs throughout the year although it is more abundant during the winter and spring. Eggs are deposited January through June and the veligers emerge with a well developed shell and velum and enter the plankton. During the winter the nudibranchs feed on the tunicate *Botryllus schlosseri* which gives the animal a chocolate brown color due to the pigmentation in the digestive gland extensions in the cerata.

C. stimpsoni was collected in large numbers from a mud flat in Edmunds, Maine. Laboratory studies indicated the adults will feed on the burrowing sea anemones *Edwardsia elegans* and *Halcampa duodecimcirrata*. Development is direct with the juveniles emerging after 52 days at 5°C.

C. salmonacea was collected at Nahant, Massachusetts in January and February. Egg coils deposited both in the laboratory and from the environment were found to develop directly after 57 days at a temperature below 10°C. The juveniles were fed the gymnoblast hydroids *Sarsia sp.* and *Bougainvillia sp.*, and differentiation of the internal organs and formation of cerata were recorded.

MOTION PICTURE OF THE COURTSHIP AND EARLY EMBRYOLOGY OF THE EOLID NUDIBRANCH *CRATENA PILATA* GOULD

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Abstract

The eolid nudibranch *Cratena pilata* Gould is a voracious predator on the scyphistoma of the sea nettle *Chrysaora quinquecirrha* of Chesapeake Bay. The film showed *C. pilata* adults feeding upon *C. quinquecirrha* polyps at half their normal speed. *C. pilata,* like most nudibranchs, is hermaphroditic and cross-fertilization of the eggs is required.

Prior to copulation, the mature adults have a characteristic courtship behavior. They touch, then recoil and again touch their oral tentacles and cerata. This courtship continues for several minutes. The nudibranchs then

[1] Supported by Northeastern University Grant ORA-8022.

come together head to head, raise up off the substrate, and join the anterior portions of their feet. They twist their bodies to bring their reproductive openings into junction. Copulation then occurs during which there is simultaneous transfer of sperm between the animals. They disengage between 30 seconds and 6½ minutes and crawl away. Both animals lay eggs after copulation, but not before.

Cleavage of the eggs was photographed with the use of time lapse attachments to an Arriflex camera (1 frame per 15 seconds) for the entire sequence. The first two cell divisions are entire and complete; the third forms four small cells at the animal pole. Later divisions are spiral, characteristic of gastropods.

The early embryos, polar bodies, and pre-veligers showed considerable activity within the egg capsule. In the later veliger stage the shell formation was photographed and in the mature pre-hatching veligers there is a well developed velum, velar cilia, clear shell, statocysts and the internal structures are relatively translucent.

The photography was done by Mr. Michael J. Reber of the Chesapeake Biological Laboratory, Solomons, Maryland. The funds were provided by the State of Maryland and United States Bureau of Commercial Fisheries under PL 89-720, as sub-project No. JF 3-1.

THE DISTRIBUTION AND DENSITY OF THE OCEAN QUAHOG, *ARCTICA ISLANDICA*

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Abstract

Bottom samples taken with a sea scallop dredge, a Campbell grab, and a hydraulic surf clam dredge from Cape Hatteras, North Carolina to the Gulf of Maine provided quantitative and qualitative information on density and distribution of ocean quahogs. The data from samples of quahogs taken by each of the three types of collecting equipment were analysed separately and the results were generally similar. The best commercial ocean quahog potential was found in an area of about 9,300 square kilometers off Long Island, New York, and New Jersey at depths of 36 to 61 meters. North of Long Island ocean quahogs were generally locally abundant and in shallower waters. South of New Jersey they were found farther offshore to northern North Carolina and were not in commercially significant numbers.

Shell lengths of ocean quahogs decreased with increased depth in the Long Island and New Jersey areas, but increased with depth southward. The largest ocean quahogs (average shell length 97 mm) were taken in the Long Island and New Jersey areas from water less than 25 meters deep, but they were few in number per station. In the Delmarva Peninsula and Virginia-North Carolina areas, the largest clams (average shell length 91 mm) were at the deepest stations, 49 to 73 meters, and were also few in number per station.

THE DISTRIBUTION AND DENSITY OF THE SURF CLAM, *SPISULA SOLIDISSIMA*

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Abstract

Intensive sampling with a hydraulic surf clam dredge delineated the distribution and density of surf clams along the middle Atlantic coast. Four geographic areas—(1) Long Island, (2) New Jersey, (3) Delmarva Peninsula, and (4) Virginia-North Carolina—are used in discussing the data. Surf clams were taken with nearly equal frequency but not in equal abundance at stations in the New Jersey and Delmarva Peninsula areas. In the Long Island area, commercial-size clams ($>$ 120 mm long) were more abundant close to shore although they occurred out to 30 meters. By contrast, in the New Jersey area the majority of large clams came from depths of 15 to 45 meters, and very dense concentrations of small clams were found occasionally at depths of less than 15 meters. Stations at depths of 30 to 45 meters in the Delmarva Peninsula area produced the largest number of large clams while stations at depths of 15 to 30 meters were next most important. In the Virginia-North Carolina area stations deeper than 45 meters produced more clams but the clams were small and not of commercial significance.

In summary, our sampling showed that the shelf off New Jersey and the Delmarva Peninsula is by far the most productive area at moderate depths.

DONAX FOSSOR, A SUMMER RANGE EXTENSION OF *DONAX VARIABILIS*

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The entire text of this report appears in Nautilus, 83:1–14, July 1969.

WEST ATLANTIC DONAX

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Abstract

Ten species of *Donax* from the Western Atlantic were discussed and illustrated by slides. Data was provided on the ecology and life history. The geographic range of each form was given and certain distinguishing characters and habitat differences were described. These would aid in identification.

A DUAL BEHAVIORAL INTERPRETATION OF A SINGLE ENVIRONMENTAL STIMULUS WITH FRESHWATER MUSSELS

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The freshwater mussel is anatomically regressed in brain development and is without multicellular visual organs. There may not be enough neurological ability, or sensory input from external stimuli such as removal from water, physical vibrations carried through sand or mud, or shadows, for the clam to consistently be closed when the stimulus is harmful (predators, poisons), or opened in beneficial cases (food, improved aeration).

Evidence exists that a dual behavioral interpretation of a single environmental stimulus occurs in practice. Upon stimulation open mussels close and closed mussels remain closed. But within an hour all mussels open, even those closed before stimulation. Thus the clam first reacts as if it were in danger and then reacts as if the stimulus were caused by something beneficial once the chance of danger has decreased.

Light

Wenrich (1916), and earlier workers documented closing of most pelecypods when a light was turned off and in half the species when the light was turned on. Braun and co-workers (1954, 1965) caused *Anodonta* and *Unio* to close with very small light changes, provided an opaque shield was passed in front of the light source very slowly. Thus the mussel appears initially to interpret the light change as a shadow caused perhaps by a predator. I studied *Elliptio complanatus* in chambers with a photoperiod similar to natural conditions (Imlay, 1968). There is a doubling of the normal frequencies of opening within an hour after light onset and light termination. In short, there is an initial negative response to light change followed by a positive permanent response.

Vibrations

Anyone who has picked up a mussel is aware of the fast closing response. Barnes (1955) showed that *Anodonta* opens after a few minutes in response to slight vibrations. I likewise found (Imlay, 1968) that *Elliptio complanatus* opens within an hour after very slight mechanical disturbance. A violent disturbance also caused most of the closed mussels to open. However, not all the open mussels reopened following temporary closure. This constitutes an exception to the general dual behavioral interpretation.

Water Change

Gartkiewicz (1922) showed that water change caused opening of *Anodonta*. Woortman (1926) found that well aerated sea water caused *Mytilus* to open but poorly ventilated aquarium water caused closing. I found that *Elliptio complanatus* similarly opens or remains open after gentle water change without disturbance even if the original water is returned. *Amblema plicata* also opened following water change.

Other Stimuli

Gartkiewicz (1922) caused closed clams to open with electrical shocks. Barnes (1955) found that small or large changes in temperature did not cause opening.

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THE EARLIEST NAMES FOR NORTH AMERICAN NAIADS

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In the time of Linnaeus 1758 there were muscles or mussels (*Mytilus*) marine and freshwater. Only a few freshwater mussels from North America had reached Europe early enough to be in Dr. Lister's 1685 picture book of shells. Perhaps the commonest species from Virginia was named [*Elliptio*] *complanatus* by Lightfoot in the Duchess of Portland Catalogue 1786. Gmelin in the 13th Edition of the Systema Naturae, 1791, named two more of Lister's figured species from Virginia [*Lampsilis*] *radiata* and [*Anodonta*] *fluviatilis.*

Spengler in 1793 renamed [*complanatus*] as *violaceus* and named another species *truncatus* to preoccupy a well known name of Rafinesque. Schumacher named the genus *Margaritifera* in 1816, but did not know it was also in North America.

It wasn't until Americans started studying the North American naiads that the names began to multiply, mirroring the much greater number of N. American species in contrast to very few in European waters. Thomas Say in the American Edition of Nicholson's Encyclopedia named several species including *alatus* and *costata* in 1817. Lamarck in 1819 named some of the common Mississippi drainage species including *ligamentina* and *luteola,* that had been sent back to France.

Rafinesque in 1818 named the genus *Potamilus* from the Ohio region; in 1819 he gave a generic outline or prodrome, and in 1820 published his "Ohio River Monograph." Unfortunately for the clarity of North American names, this was published in Brussels, in French, and was unnoticed by most American workers for some years. Rafinesque introduced 108 names (65

species and 43 varieties). He placed them in 23 generic groups, most of which we know today are biologically valid genera and subgenera.

The fog over the earliest names for North American naiads was laid down when Isaac Lea got steamed up in personal prejudice. Lea proved he knew Rafinesque's 1820 names when in 1829 he renamed one of the 3 homonyms created by Rafinesque. Barnes 1823, Valenciennes 1827, Hildreth 1828, Say 1829, Lea 1829, Swainson 1829, Say 1830, Lea 1830, and Say 1831 all published additional new names for North American species before Rafinesque in Nov. 1831 published his "Continuation of the Ohio River Monograph." In Dec. 1831 and later Isaac Lea ignored [professed ignorance of] and refused to accept any of Rafinesque's names that he could avoid in any way possible.

When Say and Conrad were sent copies of Poulson's 1832 translation of Rafinesque 1820, they published synonymies, accepting all the Rafinesquean names they could recognize from the very brief descriptions concerned. Férussac in 1835 printed his synonymy with paratypes from Rafinesque, and all of Isaac Lea's names in front of him.

The fog has continued over Rafinesque's and a few other names to the present, because some people are prejudiced against changing any part of their own status quo. As Rafinesque printed in 1820, "such naturalists cannot accept name changes made necessary by new discoveries." Bryant Walker in 1917 (Nautilus 20: 43–47) first stated and then for two pages tried to deny that Rafinesque had printed so many of his specific names under *Unio*. As a matter of simple fact many of Rafinesque's species and variety names of 1820 were printed under three generic names, and so preoccupy later names in all three genera. The binomials and trinomials of Rafinesque have been available to all since they were indexed in Binney and Tryon's 1864 reprint of Rafinesque's works on mollusks. On the other hand neither Simpson in 1900 and in 1914, nor Haas in 1969 have even listed or indexed all of the earliest names.

The efforts of Ortmann, Walker, and Pilsbry (1922) to straighten out many tangles of synonymy are seriously incomplete for two reasons. The then incomplete crystallization of the international rules allowed them to decide against first priority of dates and type-species fixations. Secondly they did not approach Rafinesque's monograph with all the Ohio and Kentucky species laid out, to determine what Rafinesque called each form. In other words they did not attempt to fix all of Rafinesque's names, but took only selected adult ones under study.

The first step out of the fog is a complete indexing of all early naiad names, particularly those published before the December 1831 work of Isaac Lea. The second step is the adoption of the earliest name for each taxon without prejudice against priority. To stay out of the fog we must use names that are not preceded by any other for the same biological taxonomic entity. If we do not accept the names of the accompanying list, the next critical student to follow can do so, and truthfully say we were not quite scientific enough.

Lasmigona badia Raf. 1831 (= *holstonia* Lea 1838)
Alasmidonta viridis Raf. 1820 (=*calceola* Lea 1829)

Alasmidonta atropurpureum Raf. 1831 (= *raveneliana* Lea 1834)
Fusconaia lateralis Raf. 1820 (= *undata* Barnes 1823)
Fusconaia pusilla Raf. 1820 (= *ebena* Lea 1831)
Fusconaia polita Say 1834 (= *subrotunda* Lea 1831 preocc.)
Megalonaias nervosa Raf. 1820 (= *gigantea* Barnes 1923)
Quadrula bullata Raf. 1820 (= *pustulosa* Lea 1831)
Plethobasus pachosteus Raf. 1820 (= *cicatricosus* Say 1829)
Plethobasus striatus Raf. 1820 (= *cooperianus* Lea 1834)
Pleurobema obliquata Raf. 1820 (= *pyramidatus* Lea 1834)
Pleurobema obliquum Lamarck 1819 (= *cordatum* Raf. 1820)
Pleurobema sintoxia Raf. 1820 (= *solidum* Lea 1838)
Pleurobema premorsa Raf. 1831 (= *plenum* Lea 1840)
Cyprogenia stegaria Raf. 1820 (= *irrorata* Lea 1829)
Ellipsaria ligamentina Lamarck 1819 (= *carinata* Barnes 1823)
Crenodonta lineolata Raf. 1820 (= *securis* Lea 1829)
Truncilla vermiculata Raf. 1820 (= *truncata* Raf. 1820 preocc.)
Potamilus alatus Say 1817 (monotype of *Potamilus* in 1818)
Potamilus ohiensis Raf. 1820 (= *laevissima* Lea 1829)
Toxolasma livida Raf. 1831 (= *glans* Lea Dec. 1831)
Lemiox rimosus Raf. 1831 (= *caelatus* Conrad 1834)
Villosa teneltus Raf. 1831 (= *taeniata* Conrad 1834)
Lampsilis teres Raf. 1820 (= *fallaciosa* Smith 1899)
Lampsilis luteola Lamarck 1819 (= *siliquoidea* Barnes 1823)
Lampsilis cardium Raf. 1820 (= *ventricosa* Barnes 1823)
Lampsilis abruptus Say 1831 (= *orbiculatus* Lea not Hildreth 1828)
Plagiola interruptus Raf. 1820 (= *brevidens* Lea 1831)
Plagiola ridibundus Say 1831 (= *sulcatus* Lea 1829 preocc.)
Plagiola perobliqua Conrad 1837 (= *delicata* Simpson 1900)
(*Epioblasma*) *flexuosa* Raf. 1820 (= *foliata* Hildreth 1828)

EARLY WORKERS ON THE NORTH AMERICAN NAIADS

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There is a rather imposing list of people who were interested in the rich naiad fauna of North America. Prior to 1800 only a very few species had been described, and these few were described by European zoologists. Thomas Say's article on conchology in the American edition of Nicholson's British Encyclopedia of 1817 was the first report by an American worker to appear in the United States. Shortly thereafter Rafinesque, a European who had been appointed Professor of Botany and Natural History in Transylvania University of Lexington, Kentucky, started to publish on freshwater mollusks of the Ohio River system. Since this early beginning there have been many who have left a heritage of material and publications regarding this important group of mollusks.

There are four rather distinct categories which form a basis for our present knowledge of this group: 1. the collectors such as T. Say, H. H. Smith, A. E. Ortmann and a host of others who had brought together much of the material upon which later studies were based; 2. the describers such as T. Say, Isaac Lea, J. G. Anthony and others who made known by the printed page the existence of the genera and species of naiads; 3. the monographers such as T. Conrad, I. Lea, C. T. Simpson who brought together in systematic order the vast amount of isolated data which had accrued during the early history of this group; 4. the geographic monographers such as T. Say, T. Conrad, R. E. Call, B. Walker, and A. E. Ortmann who worked out the patterns of distribution of the various genera and species composing the freshwater mussels of North America.

EFFECTS OF POLLUTION ON THE NAIADS OF THE ILLINOIS RIVER. William C. Starrett, Illinois Natural History Survey, Havana, Illinois.

(no abstract submitted)

EGG CASES OF *NITIDELLA OCELLATA* GMELIN AND AN *ANACHIS*

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A single adult specimen of *Nitidella ocellata* Gmelin was taken in the Key Vaca area of the Florida Keys November 26 or 27, 1968 and kept in an aerated container of sea water with several other mollusks. On January 10, 1969 egg cases were discovered, having been deposited in concealed areas such as niches in coral rocks and in the hinge sockets of clam shells. Deposits continued at intervals until mid-February with a total of twenty cases, none of which were observed at the time of deposit. The egg cases were sturdy yellowish bulbs, globular-oval, 1.5 mm long, firmly attached to the substrate at a 1 mm base plus a narrow, irregular rim. The thinner hatch area (comparatively large for the size of the case) was 1 mm in length, situated off center, rather saddle shaped, and characterized by a flaring collar. In the twenty cases found, the number of yellowish eggs varied from eight to fourteen at best count without dissection. However, no more than three embryos developed beyond the veliger stage in any one case, and no more than two juveniles hatched crawling from a single case, the third (and/or second) veliger being either underdeveloped or its shell crushed as the case became crowded.

Time of incubation was not determined but it is apparently rather long, as two cases that when discovered contained moving embryos did not hatch their crawling young until 49 days later. The smooth dark brown shell of the newly hatched averaged .8 mm in height and was about ⅔ at the overall widest. Having rasped and pushed their way through the hatch area, the young fed almost immediately on tiny crushed mussel spat (*Mytilus edulis* Linné). At three days there was new growth, showing two rows of the white spots that are characteristic of *Nitidella ocellata*.

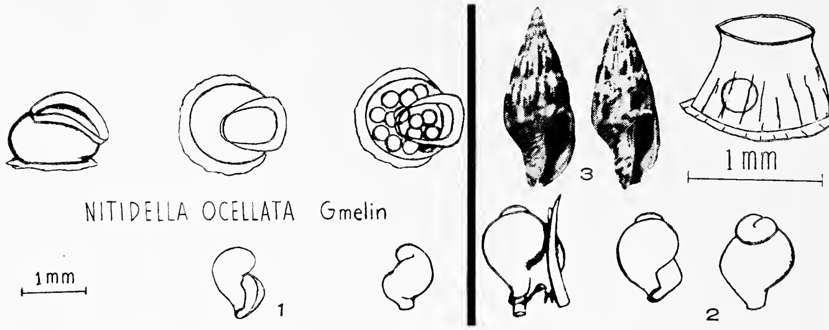

Fig. 1 Egg case and young of *Nitidella ocellata*
Fig. 2 Egg case and young of *Anachis* sp.
Fig. 3 *Anachis* sp. C. 1X

No egg cases were discovered after mid-February, 1969. Twelve specimens survive, in age to five months and in size to 10 mm and are being kept for further live observation.

Ten specimens of another columbellid were also collected in November, 1968 from the low intertidal zone of a rocky area at Grassy Key, in the Florida Keys. Four specimens survived in captivity for several months. The shell of this columbellid resembles that of *Anachis,* as does the dark animal, its behavior, and the fact that it is a carnivore. As proper identification of the species has not been made, the term "*Anachis*" is pro tem for the purposes of this report. A limited search of the literature and inquiry of a few workers in the field have as yet produced no clues.

Adults of this *Anachis* are 7½ to 9 mm in height, 3+ to 3.5 mm wide; the aperture is less than half the height; the columella is smooth. There are seven whorls, a smooth protoconch and the later whorls with low ribs which number about fifteen at the last whorl, very slightly keeled at sutures. The color is variable, ranging from a very light yellowish tan in some specimens through intermediate shades to quite dark brown in others, all well splotched with cream. The thin, tan, corneous operculum is small and perched near the posterior end of the foot. The structure of the egg cases, averaging 1 mm in height and width, also fits into the general pattern of *Anachis* cases, being shaped somewhat like an opera hat—with more or less perpendicular sides capped by the hatch which is sealed with a very narrow rim, barely projecting over the sidewall of the almost cylindrical case.

From February to mid-July approximately 200 cases were deposited by the two or three females in the aquarium. Each case held a single egg save one case which held two eggs. These two eggs did not develop to maturity.

Incubation ranged from 25 to 32 days when the fully developed young specimen, almost filling its case, spent at least a day rasping around the rim of the hatch area to emerge crawling. Average size of a newly hatched was .7 mm high and .5 mm wide, with the apertural edge so curved as to protrude slightly at its center. This protrusion was still evident at 3+ months and 5 mm in length but is not present in the adults.

These newly hatched were also fed on very tiny, crushed mussel spat (*Mytilus edulis* Linné).

FRESHWATER MUSSELS OF THE CANADIAN INTERIOR BASIN

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(Summary)

In Canada, as elsewhere, the zoogeographic regions whose limits can be defined by significant, concordant changes in the distributions of freshwater mollusks are coincident with major drainage areas. Four such drainage areas are represented. These are: (1) the Atlantic Coastal Basin which extends through the Maritime Provinces, eastern Quebec, Newfoundland, and

Drainage Systems

			Nelson Basin													
Species or Subspecies	Mackenzie River	Churchill River	Saskatchewan River	Lake Winnipegosis	Red River	Winnipeg River	Nelson River	Hayes River	Severn River	Winisk River	Attawapiskat River	Albany River	Moose River	Harricanaw River	Nottaway River	Eastmain River
Fusconaia flava	—	—	—	—	+	—	+	—	—	—	—	—	—	—	—	—
Quadrula quadrula	—	—	—	—	+	—	+	—	—	—	—	—	—	—	—	—
Amblema plicata	—	—	—	—	+	+	+	—	—	—	—	—	—	—	—	—
Elliptio complanata	—	—	—	—	—	—	—	—	—	—	—	+	+	+	+	—
Lasmigona costata	—	—	—	—	+	+	—	—	—	—	—	—	—	—	—	—
Lasmigona compressa	—	—	+	+	+	+	—	—	—	—	+	+	+	—	—	—
Lasmigona complanata	—	—	+	+	+	+	+	—	—	—	—	—	—	—	—	—
Anodonta grandis grandis	—	+	+	+	+	+	+	—	—	—	—	+	—	—	—	—
Anodonta grandis simpsoniana	+	+	+	+	—	+	+	+	+	+	+	+	+	+	+	+
Anodonta kennerlyi	+	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—
Anodontoides ferussacianus	—	—	—	+	+	+	+	—	—	—	—	+	—	—	—	—
Strophitus undulatus	?	—	+	+	+	+	+	—	—	—	—	—	—	—	—	—
Proptera alata	—	—	—	—	+	+	—	—	—	—	—	—	—	—	—	—
Ligumia recta	—	—	—	—	+	+	+	—	—	—	—	—	—	—	—	—
Lampsilis radiata siliquoidea	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	—
Lampsilis ovata	—	—	?	—	+	+	+	—	—	—	—	—	—	—	—	—

Labrador; (2) the Great Lakes-St. Lawrence Basin; (3) the Pacific Coastal Basin which extends throughout most of British Columbia and much of the Yukon Territory; and (4) the Canadian Interior Basin. The latter region comprises more than one-third of North America. It covers all of Canada not included within the other drainage areas and extends south to the headwaters of the Red River on the Minnesota-South Dakota boundary and northwest to the headwaters of the Firth River in northeastern Alaska.

The present distribution of freshwater mussels in the Canadian Interior Basin has been profoundly influenced by topography, geology, Pleistocene history, existing connections between river systems, and climate. Pleistocene features of special significance are the proglacial lakes, Lake Agassiz and Lake Barlow-Ojibway. During its period of existence from 12000 to 8000 years B.P. the boundaries of Lake Agassiz and the locations of its outlets shifted several times but its net effect was to provide wide avenues for immigration of Mississippi-Missouri Basin species into central, western, and northwestern Canada. Lake Barlow-Ojibway (8000–6000 B.P.) similarly provided access for Great Lakes-St. Lawrence species to northeastern Ontario and northwestern Quebec. (The Beringian Refugium in Yukon Territory and Alaska was also an important feature. During Wisconsin glaciation it was populated by about 42 species of freshwater mollusks, including *Anodonta beringiana* Middendorff. None of the Unionacea now living in the Canadian Interior Basin appear to have survived in Beringia, however.)

Sixteen species and subspecies of Unionidae are known from the Canadian Interior Basin. Their distributions are shown in the accompanying table.

THE FUNCTIONAL BILATERAL SYMMETRY OF THE *LAMPSILIS* MANTLE: SOME PROBLEMS

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Essentially, the question asked here is: how are the two widely separated halves of a *Lampsilis* mussel's mantle coordinated in their varied functions? The mature, gravid *Lampsilis* female exhibits "regular" activities of the mantle (*e.g.*, during siphoning, it literally "makes" its anal and branchial siphons, by bringing together the appropriate portions of its left and right mantle lobes, and holding them in siphoning position). Prior to and during spawning of glochidia, this mussel also exhibits mantle activity apparently unique among bivalves: the mantle flaps (a pair of fish-shaped extensions from the inner part of the mantle edge, immediately adjacent to the branchial siphon) exhibit rapid, rhythmic, bilaterally coordinated movements, so as to resemble a pair of small swimming minnows.

In line with a consideration of the physical basis of bilateral coordination of the *Lampsilis* mantle lobes, a brief survey of *Lampsilis* mantle anatomy and neuroanatomy was presented. It was pointed out that there is virtually no connection between the mussel's left and right mantle lobes, except for the dorsal isthmus. A thin, membranous shelf is formed between the anal (supra-branchial) and branchial cavities; but this shelf contains only the paired branchial nerves, which fuse posteriorly. It seems doubtful that this

septum can be implicated in the functions of the distal portions of the mantle lobes (*e.g.* the portions which function as siphons or as mantle flaps). As in other freshwater bivalves, three pairs of ganglia, joined by long connectives, are located in the midline of the body. Pedal ganglia and visceral ganglia are fused, while the cerebral ganglia are separated by a horizontal commissure which passes under the mouth. Cerebral and visceral ganglia send many paired nerves to the periphery of the mantle.

Lampsilis is capable of processing a number of stimuli (light, tactile sensations) to which its mantle responds in a bilaterally coordinated way; but how environmental stimuli are detected by *Lampsilis* is a puzzle (as it still is in other unionids). Slides were shown to demonstrate that a statocyst nerve emanates from each cerebral ganglion, and the nerve's fibers actually enter the connective tissue capsule of a statocyst, where they fray out among the tall, presumably sensory epithelial cells of the organ's interior. Though the pair of statocysts may help the mussel to orient itself in the substrate, it seems unlikely that they may be involved in bilateral response to sensory inputs from the mantle edges, either during normal behavior, or during mantle flap activity of the animal.

In addition to the paired statocysts, one finds descriptions in the literature of at least 5 other paired "sense organs" in the unionids: osphradia, abdominal sense organs, lateral sense organs, oral sensory ridges, and adoral sense organs. Since neither the innervation nor the function (with the possible exception of the osphradia) seems to be known, one is tempted to wonder whether or not just any patch of tall epithelial cells should be called a "sense organ." In adult female *Lampsilis* the prominent eyespot on each mantle flap constitutes yet another pair of such distinctive epithelial patches; yet I have no convincing behavioral or physiological evidence that the eyespots are true sensory receptors. The conspicuous basement membrane which underlies mantle epithelium adjacent to the eyespots, disappears in the region of the eyespot epithelium; but to date my experiments with techniques to demonstrate nerve fiber innervation of the eyespot epithelia have been unsuccessful.

Examination of the posterior portions of the two mantle lobes in *Lampsilis* has revealed the presence of a pair of mantle ganglia, described previously in *L. ventricosa* (Kraemer, L. R., AMU Ann. Rep., 1967, p. 42) adjacent to the mantle flaps. It is here reported that the mantle ganglia have been found in *L. cariosa, L. siliquoidea,* and *L. fasciola,* but not in other unionids examined by this author (including *Carunculina parva* and *Amblema costata*).

Since there are virtually no neural pathways which could provide the remarkable bilateral coordination of both siphonal and mantle flap activities in *Lampsilis,* other than those which pass through the visceral ganglion, it seems likely that the visceral ganglion must integrate signals from the *Lampsilis* mantle edge. However, because of their location, which coincides with the point of origin of both spontaneous, rhythmical flap movements, and induced mantle flap movements (by shadows, etc.), it seems reasonable to suggest that the mantle ganglia may mediate all mantle flap movements.

Neurophysiological evidence for the central coordination of the two lobes of the naiad mantle is needed, as well as both physical and physiological information about sensory input mechanisms. Though the naiad's lack of

much mantle fusion especially in the region of the siphons has often been regarded as primitive, it is here suggested that our knowledge of the behavior, neuroanatomy and neurophysiology of the unionid mantle is still quite primitive. *Lampsilis* in particular, seems to exhibit complex behavioral physiology in the functional bilateral symmetry of its mantle.

GONAD DEVELOPMENT IN THE THREE-RIDGE NAIAD, *AMBLEMA PLICATA* (SAY, 1817)

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Permanent histological sections of the gonad region of the visceral mass have been prepared and studied to determine the age at maturity, rate of gonad development, and incidence of hermaphroditism in the naiad *Amblema plicata* (Say, 1817).

The youngest specimens studied were three years old, as determined by the annular rings on the shells. None of the nine three-year-old specimens was sexually mature. Most of them possessed undifferentiated primary gonads; a few could be tentatively distinguished as males or females, but none possessed mature gametes.

The youngest female with clearly differentiated ovaries was a four-year-old, 52 mm long, in which primary gonia were differentiating into young oocytes and were bulging into the lumina of the ovarian follicles. Ripe oocytes were found in five-year-old and older females. In mid-June and early July many ripe oocytes break off from the follicle walls and pass through the ciliated oviducts to the gonopores. There does not seem to be any resting period between ovulation and the beginning of oogenesis for the next year's egg crop. Specimens with blastula-stage embryos in the gills already contain enlarged oocytes in the lumina of the ovarian follicles.

The youngest recognizable male specimen was three years old, 34 mm long. It possessed some spermatocytes in the testicular follicles, but no mature spermatozoa were present. No four-year-old male specimens have been examined. Mature sperm are present in the testicular follicles of five-year-old males. It seems probable that sexual maturity is attained during the fourth year in males, as well as in females.

Of 148 *A. plicata* examined from western Lake Erie, four were found to contain both ovarian and testicular follicles in the gonads. Two of these specimens appeared to be producing both normal spermatozoa and normal eggs at the time of collection. The other two appeared to be functioning as males, with undeveloped or immature ovarian follicles also present. In all four hermaphroditic specimens the testicular follicles were distinctly separate from the ovarian follicles, and no mixed follicles were seen. Several hundred specimens from the Walhonding, Muskingum, and Ohio Rivers have been examined, and no hermaphroditic individuals have been found in the populations from these rivers.

HISTOLOGICAL STUDIES OF THE NEPHRIDIUM AND PERICARDIAL LINING OF *QUADRULA NODULATA*

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Abstract

Histological examination of the epithelium of the nephridium and the lining of the pericardial cavity of *Quadrula nodulata* (Rafinesque, 1820) revealed excretory activity on the cellular level. Apparently materials are ingested by certain cells, enzymatically broken down, and excreted by way of constriction of secondary vesicles into either the nephridial lumen or the pericardial cavity. The cells, as observed, are of three types: (A) Simple ciliated columnar cells which contain a large, granular, centrally located nucleus with one to two nucleoli. This type was found to be the most numerous, distributed at random in nephridial epithelial tissue, pericardial lining, and also lining the nephridiopore and the nephrostome. (B) Simple columnar cells containing a large, non-granular vacuole which displaces the nucleus laterally and ventrally to a basal position. This type of cell appeared mainly in the posterior region of the nephridium and less frequently in the lining of the pericardial cavity. The constriction of secondary vesicles off these cells and their liberation into the lumen of the nephridium or the pericardial cavity was observed. (C) Simple columnar cells abundant in the nephridial tissue and the lining of the pericardium, in close contact with the blood of the pericardial sinus. Secondary vesicles containing granular materials are constricted off these cells.

HOW TO FIND FRESHWATER MOLLUSKS IN CREEK-SIZE STREAMS

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The term 'Creek-size Streams' as used herein, applies to streams ranging from large brooks or branches to small rivers. Various types of equipment are needed in order to do any appreciable amount of collecting in freshwater. Standard equipment usually comprises a pair of hip boots, a glass-bottomed bucket, a long handled sieve, a vial or two and one or several cloth bags. In hot weather, I use shorter boots and a bathing suit, allowing the boots to fill with water. While in cool weather one may use boots primarily to keep his feet dry and warm, but an additional purpose is to protect one's feet from sharp objects and reptiles. A round bucket with a bail-type handle is most convenient for carrying. The glass bottom should be constructed of tough automobile safety glass and placed at the wide end of a tapered bucket. This bucket has many uses. Visibility of the stream bottom becomes much plainer as it removes sky and wave reflections. On gravel bottom, use of the bucket saves much wear and tear on the fingers. Most mollusks may be seen so that one need not pick up dozens of pebbles for every mollusk taken. The bucket makes a convenient temporary receptacle for one's catch. When

the catch starts to obscure one's view too much, one has simply to place the larger mollusks in a bag. The bag may then be set in a noticeable place on the stream bank, to be collected upon one's return downstream.

When collecting in a gravelly bottomed stream where bivalves are common, it is often advantageous to use a hoe to rake over the bottom. After the water above the area hoed clears, one can more easily spot smaller bivalves, especially juveniles and finger nail clams. A collection of juvenile unionids is important for the study of their beak sculpture.

A long handled sieve with a straight edged scoop is handy for use in mud and during cold weather. The sieve is the practical answer for collecting finger nail clams. These mollusks often live in mud among the roots of plants. After picking up a scoop full of mud, one should undulate the sieve in the water until the finer debris is removed through the wire mesh. As the heavier mollusks remain on the bottom, vegetation may then be floated out of the sieve. It should be submerged in the stream and moved against the current slowly and briefly. Most mollusks may then be separated from the heavier gravel by tilting the sieve and moving it through the water rapidly and briefly without submerging it again. After the larger debris has been removed by hand, the blade of one's pocketknife may be used to remove the smaller mollusks.

Before embarking into the field to collect, one should be well equipped with maps. Many federal governments sell topographical maps which show much detail. These details often provide the collector with considerable information as to where one may find shoals in a stream and access roads or trails leading to them. Fords or ford sites, where shoals may generally be found, are usually shown. One may also note shoals on a map where a bend in the stream is shown and adjacent land contours indicate a dropping off point in a valley or gorge. Some topographic maps indicate shoals.

Upon arriving on a selected site, one should check the different physiographic features of the site. The molluscan fauna of one feature may differ somewhat from another. These features may be divided as follows:

1. Ponded part of stream:

Here when the water is clear, one can often work visually without the assistance of a glass-bottomed bucket. This type of site may yield specimens that live under either shoal or slack water conditions. The ponded area immediately above a run is generally one of the most lucrative collecting sites. Deep sections may be collected by feel, using one's hand or foot.

2. Riffle part of stream or shoals:

Collecting here is generally best adjacent to the bank, especially the bank of an island or bar. One may find unionids most common just behind the edge of swift water where the current is slackened by a point of land or other obstruction above. While unionids are often less common away from the bank of a stream, this statement does not always hold true. Some genera are usually found only in swift water. There are a few species of mollusks which may be found alive only under rocks or other objects in very swift water. Some of these cling to the undersides of rocks, while others may be found imbedded in sand, mud or clay beneath rocks, overhanging strata

or other form of submerged structure. Some of the gastropods which live here are nocturnal and emerge to feed at night.

The silt-free areas below and beneath stream obstructions such as logs, rocks, bridge piers, etc. are frequently inhabited by swift-water loving mollusks. This factor may be particularly important in swift streams where silting is persistent. In other areas, the persistent silting smothers most mollusks, especially unionids, which move into such unsheltered areas. Another type of barrier which provides shelter for mollusks may be formed by a sharp bend in a stream. Silt will make a wide sweep around the outside of the bend when it is situated in a swift stream. Beneath the bank at the inside of the bend, below the usual sandbar, one may find mollusks living protected from smothering silt or sand.

3. Submerged sandbars:

This type of habitat is more generally found in the larger streams. The species which live here continually move about so that they are able to stay above the average amount of shifting sand moving across the bar. Plainly visible furrows are created by unionids here.

4. Stream fringe areas:

The fringe area of a stream is usually richest in vegetable and animal detritus. Many genera are pretty well restricted to this type of habitat. This is particularly true of pulmonate gastropods, some unionids, and the fingernail clams. Here the use of a sieve is strongly advised. One is often amazed at the amount of fine mollusks that is to be found amongst grass roots, fine sand and often muck of the stream bank. One must not overlook submerged rotten logs, especially cherry logs. The genus *Campeloma* is usually found burrowing in rotten cherry logs in large numbers.

LATE PLEISTOCENE NONMARINE MOLLUSKS FROM LAKE BRETZ, LOWER GRAND COULEE, WASHINGTON

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Nonmarine mollusks comprising a total sample population of more than 85,000 individuals were collected near a barrow pit, L65-1, at the east wall of Lower Grand Coulee, Washington during October 1965. Other samples of mollusks were obtained from deposits located throughout the Lower Grand Coulee in 1966–1969. Sediments from which this molluscan assemblage was obtained, consisted of silt, coarse volcanic ash, and shell. Previous studies have identified the volcanic ash to be of Glacier Peak origin and place its age and that of the associated shells at about 12,500 years before present. The shell was separated from the sediment by washing, drying, screening, and sorting. Diatoms, ostracods, fish, and plant remains were also recovered. At least 20 species of nonmarine mollusks, representing 12 genera were found in the three meter section. Pelecypods were represented by two genera, *Anodonta* and *Pisidium,* while seven genera of aquatic gastropods were also found including

Valvata, Lymnaea, Gyraulus, Armiger, Vorticifex, Planorbella, and *Physa.* Of the mollusks sampled there seems to be no dramatic change in the types of mollusks. However, there is a general build up of numbers of individuals in the population so that there are 20,109 in layer "D."

Mollusks from other localities in the Lower Grand Coulee also aided in the interpretation of the Pleistocene deposits. North of the primary locality, near Sun Lakes State Park, an outcrop of mollusks, volcanic ash, and silt showed a proportional increase in the number of *Vorticifex* and an increase in the shell thickness of the *Anodonta* compared to the primary assemblage, L65-1. This indicates that there was more current and oxygenation taking place in this area near Sun Lakes State Park than at L65-1.

From the faunal and geological evidence, it appears that these deposits are of lacustrine origin. The source of the water for this lake, Lake Bretz was, for the most part, the Columbia River. There are indications that the Columbia overflowed its canyon near the present site of Grand Coulee Dam. The cause of this was the downstream ponding of the Columbia in Lake Lewis. This overflow then supplied Lake Bretz with water at a fairly slow current. Lake Bretz was then drained through Rocky Ford Coulee to Moses Lake and later into Lake Lewis. When the latter lake ceased to exist, Lake Bretz without its supply of water gradually became smaller, breaking up into the present five or six small lakes. These lakes, Bretz and Lewis, probably lasted only 50–100 years. The highest stable lake level of Lake Bretz was 1158 $\pm$ 1 feet. This was determined through the use of U. S. Geological Survey quadrangle maps and Bureau of Reclamation surveys. Lake Bretz is named in honor of J Harlen Bretz, who did so much of the early work on the Pleistocene in eastern Washington and the Channeled Scablands of Washington.

Only three species of terrestrial gastropods were found and were represented by a total of eleven individuals. Their occurrences are best explained by chance washing of dead shells into the lake from adjacent land. These mollusks indicate only that there was probably some vegetation near the edge of Lake Bretz.

LIFE HISTORY OF *PLEUROBEMA CORDATUM* (RAFINESQUE, 1820) (BIVALVIA: UNIONIDAE)

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Abstract

The Ohio Pigtoe Mussel, a commercially valuable species, inhabits the largest rivers of the Ohio River drainage system, and occurs in concentrations or "mussel beds" in the Tennessee River. Oogenesis and spermatogenesis occur at cyclic intervals throughout the year with spawning and fertilization in April and May. Glochidia are formed in four to six weeks after fertilization in the marsupial outer gills. The parasitic glochidia, released mainly in June, attach to the gill filaments of the Rosefin Shiner, *Notropis ardens* (Cope), encyst, and transform into independent mussels in fourteen to eighteen

days. A motile foot is developed during encystment but no increase in overall size results. Within three weeks after dropping from the host fish, the free-living naiads double in size. Sexual maturity is reached within four years and gonads remain functional throughout the mussel's remaining twenty-five to thirty years of life.

NOTES ON THE LIFE HISTORY OF *TRUNCATELLA CARIBAEENSIS* REEVE[1]

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Truncatella caribaeensis is a small prosobranch gastropod, distributed throughout much of the Gulf and Caribbean regions, and occurring under plant debris at the upper reaches of the high tide. Since members of this genus live in an intermediate type of environment with a variety of life history modifications possible, and since no members of the genus have previously been examined from the viewpoint of life history, such a study was considered desirable.

Specimens were collected and ecological observations were made along the Florida west coast from the panhandle to the Keys. At one locality, St. Marks Wildlife Refuge in Wakulla County, ten periodic collections were made over a period of about a year for purposes of population analysis. Laboratory cultures were also initiated, using Petri dishes with a variety of substrates.

The drift zone habitat encompasses a wide array of physical conditions, some of which are limiting to the distribution of *Truncatella caribaeensis.* The most significant of these seem to be moisture, salinity, and shading. *Truncatella* is capable of withstanding a very wide range of moisture conditions, from total immersion to a lack of free water, for considerable periods of time (Lowe, 1832), but does not naturally occur under such circumstances. Usually *T. caribaeensis* is found in slightly damp debris with a wet weight moisture content of from 50% to 75%. Salinity varies greatly within the drift zone over very short distances due to the opposing effects of deposition by spray and leaching by rain. In those areas of drift in which *T. caribaeensis* normally occurs the salinity of the moisture contained in the debris varies between about ten and twenty parts per thousand. This species of snail is invariably found in areas with at least partial shading, and is most numerous where heavy shade is available. This preference is probably correlated with high temperatures in exposed drift and concomitant low moisture and high salinity. Along the Florida coast the drift consists of decomposing leaves and other fragments of mangrove, turtle grass, sargassum, and other plants in lesser quantities. This material tends to be deposited in layers, and *T. caribaeensis* is most common in the less compact areas between layers. Prob-

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ably due to the rather harsh conditions within the drift, coinhabitants with *Truncatella* are often prolific in numbers of individuals but limited as to numbers of species. These include amphipods, mites, pseudoscorpions, various ellobiid gastropods, millipedes, beetles, isopods, small shore crabs, and *Littorina* (especially juveniles), in about that decreasing order of abundance. Specimens of *T. caribaeensis* found in very wet areas often have the foraminiferan *Discorinopsis aguayoi* attached to their shells.

Analysis of the St. Marks population indicates the presence of a rather diffuse breeding season centered about the period between late winter and early spring. No eggs were found in the field, but they were produced in laboratory cultures during the late spring. These were deposited singly, and were normally partially buried in the substrate which consisted of either damp sand or mud, overlain by plant debris. The eggs are spherical, about 0.75 mm in diameter, and very translucent. No more than about fifteen eggs were observed to be produced by any one snail. The low number of eggs is probably related to their relatively large size. Hatching occurs in a few days and the newly emerged snails are globose with a diameter of about 0.6 mm. Within ten days a shell length of 1.0 mm is reached. Further growth is slower, and averages 0.03 mm of length per day. The shell shape rapidly becomes elongate as the line of sutural attachment becomes progressively lower during growth of the first two or three whorls. Almost full growth is attained in about 200 days, and the total life span is probably about a year.

Truncation, involving the removal of the upper four or five whorls, takes place when a shell length of five to six mm is reached. This phenomenon is probably useful in producing a more compact shell. The mechanism of truncation is not known, but some data are available. The body of the animal gradually withdraws from the upper region of the shell as the shell length approaches 5 mm. A calcareous septum is then secreted at the upper end of the body, and truncation shortly follows in most instances, although untruncated adults may occasionally be found with very fragile and often chalky appearing apices. These unusual specimens are much more numerous in soft, lightly packed debris than in hard and compact material.

Colonies of *Truncatella caribaeensis* are very sporadically distributed even in areas where suitable habitats are readily available. This undoubtedly reflects the lack of an aquatic state in the species. Dispersal seems to be primarily effected by mass movements of the debris in which the snails live, and populations are therefore subject to rapid change.

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MALACOLOGY TODAY. Dee Dundee, Louisiana State University, New Orleans.

(no abstract submitted)

METHODS OF SUBFAMILY RECOGNITION IN PACIFIC ISLAND ENDODONTID LAND SNAILS

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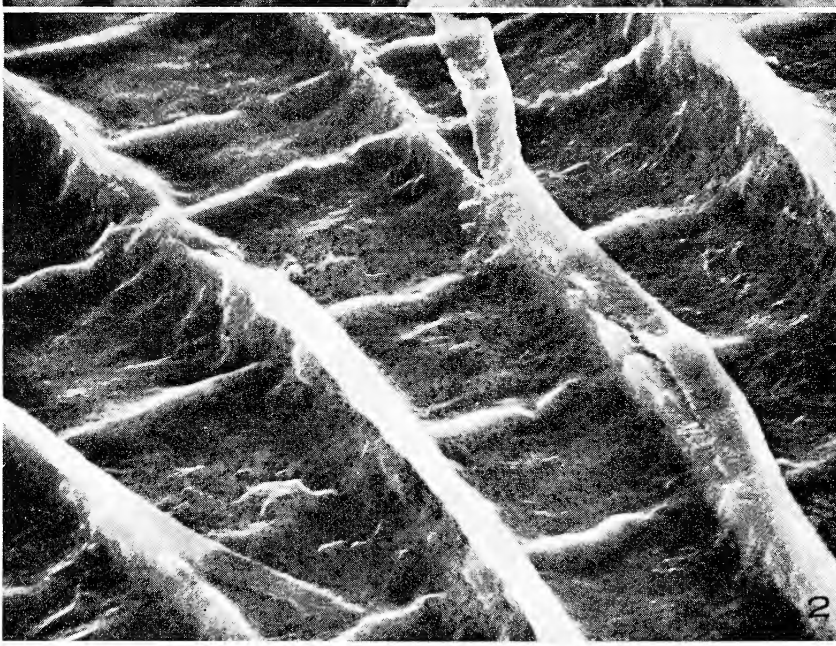
Several years of study on the Pacific Island endodontid land snails has resulted in the recognition of 275 species and subspecies, of which 151 were previously undescribed. Dissection of about 35% of the taxa showed there were two subfamily groupings with major differences in the pallial complex and genital structures. These differences correlate with habitat selection and reproductive habits. Even fragmentary portions of the terminal genitalia are sufficient to demonstrate subfamily position. One subfamily, the Endodontinae, is confined to leaf litter niches except under conditions of very high rainfall. The other subfamily, the Charopinae, occurs both in leaf litter and also on tree trunks up to 15′ above the ground level.

Many species are represented in collections only by empty shells. Fossils from the deep cores on Bikini, Eniwetok, and Funafuti obviously could not be dissected, and many species collected as recently as the mid-1930's are now extinct. A major problem concerned the search for conchological characters that would predict subfamily position. Since the distributions overlap and both groups inhabit the leaf litter zone at least in part, the shells have been subjected to the same selective pressures.

During the systematic analysis, several shell measurements and ratios were taken for all adult specimens. Means were calculated for each species-level unit and the data transferred to IBM cards. Comparisons of the species means within and between subfamilies were readily accomplished. To minimize the effects of extremely large or small species, median species measurements for each subfamily were utilized in this analysis. In regard to the ratio of Shell Height to Shell Diameter, the ratio of Shell Diameter to Umbilical Width, the number of ribs on the body whorl, and the frequency of rib spacing, the medians are virtually identical in the two subfamilies. The Endodontinae do have a significantly larger whorl count, correlating with the pallial complex differences, and have larger median size, but there is sufficient overlap between the subfamilies that limited predictive value can be assigned these features. Most litter species have large and complex denticles within the shell aperture. Over 99% of the Endodontinae have these denticles, but only 33% of the Charopinae. While "toothless" species probably belong to the Charopinae, "toothed" species show no consistent differences in tooth form or size and thus cannot be assigned to subfamily. No gross meristic characters or morphologic features visible under light microscope examination were discovered that would enable subfamily recognition.

Use of the scanning electron microscope at 300–10,000× magnification revealed one character in the shell microsculpture and another character in the tooth structure that enabled subfamily placement without question. Convergence in shell form, sculpture, size, denticles and coiling pattern is so marked that subfamily classification of fossil and recently extinct species has been done on the basis of two submicroscopic shell features. Adansonian or phenetic comparisons of shells belonging to these subfamilies result in com-



1. Postnuclear surface sculpture on the spire of a 2 mm. endodontid snail from Biak, West Irian, at 1,000× magnification.

2. Apical sculpture of an undescribed species from Henderson Island, Polynesia at 3,000× magnification. Note the flaking periostracal layer.

pletely erroneous classifications. A general conclusion is that classifications of fossil mollusks based on overall similarities may be equally unrelated to reality and that identification of conchological key characters correlated with anatomical structures in living species should be a prerequisite to systematic revision of Cenozoic mollusks.

MORPHOLOGICAL-TAXONOMIC NOTES ON VARIOUS FRESH-WATER PULMONATE SNAILS. Harold J. Walter, Dayton, Ohio.

(read by title)

THE MOLLUSCAN FAUNA IN NORTH CAROLINA'S NEUSE RIVER ESTUARY

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To investigate a suspected heavy mortality of *Macoma balthica* Linné and to gather ecological and distributional data on molluscan species inhabiting the estuary while still unpolluted by industrial and domestic contaminants, a survey was begun in November of 1967. In the study area, from a point above the city of New Bern to the mouth of the Neuse, salinities varied from 1 to 23%; subsurface salinities frequently were 6 higher than surface salinities; temperatures ranged between 6 and 29°C. The estuary was divided by 12 transects, each three to four miles apart. When possible, samples were taken from three locations on each transect: a sandy, south shoal area (5–10 ft. depth), a muddy channel area (over 10 ft. depth) and a sandy north shoal area (5–10 ft. depth); in 1969 additional samples were taken from beach areas (1–3 ft. depth). During four collecting cruises (Nov. 1967; May and Sept. 1968; June 1969) 112 samples were taken. Beach areas were sampled by shovel, shoal and channel area by shell dredge and/or Peterson grab. The following were collected:

Anadara ovalis Bruguière	F	*Petricola pholadiformis* Lamarck	F
Amygdalum papyria Conrad	F	*Mya arenaria* Linné	M
Brachidontes recurvus Rafinesque	M	*Cadulus quadridentatus* Dall ?	F
Crassostrea virginica Gmelin	C	*Littorina irrorata* Say	M
Phacoides multilineata Tuomey and Holmes	F	*Epitonium rupicola* Kurtz	M
Macoma balthica Linné	C	*Mitrella lunata* Say	F
Macoma phenax Dall	C	*Nassarius vibex* Say	M
Mulinia lateralis Say	C	*Acteon punctostriatus* C. B. Adams	M
Rangia cuneata Gray	C	*Haminoea solitaria* Say	F
Tellina agilis Stimpson ?	F	*Retusa canaliculata* Say	C
Tagelus plebeius Lightfoot	F	*Sayella chesapeakea* Morrison	M
Mytilopsis leucophaeata Conrad	M	Unknown gastropod	M
Gemma gemma Totten	C		

(C = common; M = moderately abundant; F = few, 1–5 individuals)

The major *Macoma balthica* population, occurring between Flanner's Beach and the town of Oriental, occurred in an area where subsurface salinities averaged 8–13%. Here a density of 1,500/M² occurred in one sample. Major mortalities, noted in 1967 and 1968, are believed to have been caused by a lack of dissolved oxygen in subsurface waters during early summer months.

Macoma phenax occurred with the *M. balthica* population but in smaller numbers. *M. phenax* showed a slight preference for salinities higher than those inhabited by *M. balthica*.

The major population of *Rangia cuneata* occurred between New Bern and Wilkinson Point; below Wilkinson Point it was gradually replaced by *Mulinia lateralis*. Average subsurface salinity at Wilkinson Point is 11.7‰. Maximum recorded density of *R. cuneata* was about 300/M² and about 50/M² for *Mulinia lateralis*.

Gemma gemma was found only in the sandy shoal and/or beach areas from a locality having an average salinity of 13‰ (Cockle Point) to the mouth of the river. *Gemma* density did not go over 125/M².

The opisthobranch, *Retusa canaliculata*, was the only gastropod occurring in any number. This species was common in the vicinity of the Clubfoot Canal (average salinity about 14‰) to the mouth of the river.

PRELIMINARY REPORT ON THE DISTRIBUTION OF LAND SNAILS IN NORTHERN MISSOURI

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There has been no major attention directed toward the land snail fauna of Missouri since the early part of this century (Pilsbry and Ferriss, 1906; Sampson, 1913). Although numerous records have been published pertaining to the southwest, central and southeastern portions of the state, there remain large areas for which few or no published records of land snails are to be found. Especially noteworthy is the paucity of information pertaining to the fauna of northern Missouri. Only a few records exist from 11 of the 44 counties situated north of the Missouri River.

During the Spring of 1968, a series of collecting trips was conducted throughout northern Missouri. Fifty localities, located in 29 counties, were investigated and all snails collected were identified and incorporated into the Mollusk Collection, Department of Biology, UMKC. Distribution studies suggested the existence of two distinct land snail faunas, separated by a boundary extending through Boone, Audrain, Monroe and Marion counties (Miles, 1969). Further studies have been conducted during the Spring and Summer of 1969. Additional evidence has been gathered confirming the existence of the two faunas, designated as Northwestern and Northeastern. To date, 94 localities north of the Missouri River have been investigated. Studies are also in progress south of the river.

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Table I

Predominant Species in the Northwestern Fauna
(37 localities)

Species	Number of Localities	% Occurrence
Stenotrema leai aliciae (Pilsbry)	22	59
Zonitoides arboreus (Say)	20	54
Retinella indentata (Say)	20	54
Helicodiscus parallelus (Say)	12	32
Retinella electrina (Gould)	11	30
Anguispira alternata (Say)	11	30
Gastrocopta armifera (Say)	10	27
Succinea ovalis Say	9	24
Mesodon clausus (Say)	7	19

A total of 35 species of land snails (excluding slugs) now have been collected in northern Missouri. Some species range across the entire northern portion of the state and are common to both the Northwestern and Northeastern faunas. Nevertheless, the faunas differ in two respects: (1) Certain species are more abundantly represented in one fauna than in the other; (2) other species appear to be absent from one or the other fauna.

Nine species predominate in the Northwestern fauna (Table I). *Stenotrema leai aliciae* (Pilsbry) has been found in more localities than any other species (59%), followed by *Zonitoides arboreus* (Say) and *Retinella indentata* (Say) (54% for both). Several other species characteristic of the Northwestern fauna, including *Triodopsis albolabris* (Say), were not included in Table I because they occurred in less than 20% of the localities.

The Northeastern fauna is characterized by the occurrence of *Mesodon thyroidus* (Say), *M. inflectus* (Say) and *M. elevatus* (Say) (Table II). *Mesodon thyroidus* has been collected in more localities than any other species.

Table II

Predominant Species in the Northeastern Fauna
(41 localities)

Species	Number of Localities	% Occurrence
Mesodon thyroidus (Say)	20	49
Anguispira alternata (Say)	16	39
Retinella indentata (Say)	12	29
Triodopsis albolabris (Say)	11	27
Mesodon inflectus (Say)	10	24
Zonitoides arboreus (Say)	10	24
Stenotrema fraternum (Say)	9	22
Haplotrema concavum (Say)	9	22
Mesodon elevatus (Say)	9	22

Anguispira kochi (Pfeiffer) also occurs in this fauna. None of these species have been found within the area occupied by the Northwestern fauna. *Haplotrema concavum* (Say) occurs in large populations in the Northeastern fauna and *Stenotrema fraternum* (Say) is the most abundant representative of its genus in that fauna.

Species occurring in both faunas include *Anguispira alternata, Gastrocopta armifera, Retinella indentata* and *Strobilops labyrinthica* (Say). Several species common in the Northwestern fauna appear only rarely in collections from the Northeastern fauna, including *Stenotrema leai aliciae, Helicodiscus paralleus,* and *Retinella electrina.*

A correlation between total annual precipitation and the distribution of land snails comprising the two faunas has been noted (Miles, 1969). The Northwestern fauna occupies that portion of the state receiving an average total annual precipitation of 37 inches or less, while the species characteristic of the Northeastern fauna occur where the average is 38 inches or more. The 37 inch precipitation line marks the boundary between the two northern faunas. The species characteristic of the Northeastern fauna also range south of the Missouri River into portions of the state receiving annual precipitation in excess of 38 inches. The hypothesis is proposed that total annual precipitation of 37 inches may be an important factor in the distribution of land snails in northern Missouri.

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PARAMYA SUBOVATA, A COMMENSAL WITH THE ECHIUROID *THALASSEMA HARTMANI*[1]

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The occurrence of *Paramya subovata* (Superfamily Myacea) as a commensal bivalve reported here is of special interest since it is a non-leptonid. The majority of commensal bivalve mollusks belong to the superfamily Leptonacea (= Erycinacea).

In contrast to typical, ciliary, filter-feeding bivalves, representatives of the Leptonacea have an anterior, inhalant current and thus a "straight-through" pattern of water flow through the mantle cavity. In addition the foot is adapted for crawling rather than burrowing. The possession of these attributes

[1] Supported by a research grant from the University Research Council, University of North Carolina.

seems to explain the tendency for representatives of this group to live as commensals in the burrows of various invertebrates. Boss (1965) has given a useful summary of such commensal relationships.

Cryptomya californica Conrad is an example of a non-leptonid bivalve which, in contrast to leptonids, is a burrowing species. It occurs on the west coast of this country as a commensal with the crustaceans *Callianassa californiensis* and *Upogebia puggettensis* and with the echiuroid *Urechis caupo* (MacGinitie, 1934, 1935). Although both inhalant and exhalant siphons are extremely short, *Cryptomya* lives at depths in the substrate up to 50 centimeters. This is accomplished by drawing its water supply from the burrow of the host, the only such commensal relationship thus far known (Yonge, 1951).

At Wrightsville Beach, North Carolina we have found *Paramya subovata* Conrad living as a commensal with the echiuroid *Thalassema hartmani* in a relationship that is similar to that shown by *Cryptomya* with its hosts. The majority of specimens of *Thalassema hartmani* which we have dug in the intertidal zone at Wrightsville Beach are found to have these small clams (to ca 11 mm in shell length) present in the sediments adjacent to the burrow of the echiuroid, with the short, posterior, exhalant and inhalant siphons opening into the cavity of the burrow. As many as five bivalves have been found with a single echiuroid. *Paramya subovata* seems to be more host specific than its west coast counterpart. The callianassid *Upogebia affinis* is common on the same intertidal flats where *Thalassema hartmani* is found, but thus far *Paramya* has been found only with the latter species.

Although *Cryptomya* and *Paramya* are placed in the same superfamily, the latter lacks the shelf-like chondrophore on the left valve which is present in *Cryptomya* and which characterizes the Myidae. It is thus clear that this type of commensalism has evolved independently within the Myacea and therefore presents yet another example of evolutionary convergence in the phylum Mollusca.

PATTERNS OF OXYGEN CONSUMPTION OF THE FRESHWATER PULMONATE SNAIL, *LYMNAEA PALUSTRIS*

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Abstract

The Warburg constant volume respirometer was used to measure oxygen consumption of the fresh water pulmonate snail, *Lymnaea palustris*. The lab-reared snails were treated on an individual basis. No pooled samples were used, nor was the data plotted on a log-log basis or cumulatively. Oxygen measurements were made hourly and the data were plotted on an interval basis as μl of oxygen per hour per individual.

Three patterns of oxygen uptake were observed among respiratory curves for individual snails. One pattern was of two hours duration and the other two patterns were of three hours duration. Of 477 hours of recorded data,

95 per cent of the time was accounted for by these three patterns. The patterns appear to be of an endogenous origin and may possibly be associated with growth. A computer method was used to establish a hypotential model of the daily respiratory curve of the snail. This was done by matching experimental data to hypotential master models. The model with the greatest number of snail data matching was selected as the respiratory curve most likely to represent the snails daily respiratory curve.

PHILOPHTHALMUS SP. (TREMATODA) IN *TAREBIA GRANIFERA* AND *MELANOIDES TUBERCULATUS* IN SOUTH TEXAS

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Tarebia (= *Thiara*) *granifera* and *Melanoides* (= *Thiara*) *tuberculatus* are two species of Oriental snails established in several areas of the southern United States. Both species are intermediate hosts for several trematode parasites of man in the Orient. They were first reported in South Texas by H. Murray (Annual Report, American Malacological Union, 1964). These snails are abundant immediately outside the San Antonio Zoo in Brackenridge Park, San Antonio, Bexar County, Texas. Ever since their detection both inside and outside the zoo in 1964, they have been intensely investigated by H. Murray.

In April 1968, A. Stewart, Trinity University, recovered rediae from *T. granifera* collected near the San Antonio Zoo. This information was reported to the AMU by H. Murray and A. Stewart (Annual Report, American Malacological Union, 1968). At that time, it was presumed that the adult trematode occurred in waterfowl but neither the adult nor the life cycle of the parasite were known.

Subsequently, in September 1968, an intensive study was undertaken to determine the species, life cycle, and importance of this trematode to the San Antonio Zoo and to the city of San Antonio. The San Antonio Zoo occupies approximately 130 acres of land and houses approximately 100 species of waterfowl, along with many other animals. Within the zoo an artesian well discharges 1850 gallons of water per minute and provides the zoo with waterways for natural settings of waterfowl. The water from the zoo is discharged into the San Antonio River by two exists, referred to as the northern and southern effluents. The San Antonio River travels through the metropolitan area of the City and eventually enters the Gulf of Mexico.

Because the number of infected snails decreases in relation to the distance from the zoo and because there are few infected snails at the southern effluent, it has been concluded that the site of the adult trematode is the northern part of the zoo. In some areas of the northern effluent one out of every three *T. granifera* is heavily infected with rediae. In most instances, each snail is so heavily infected that there is no discernable digestive gland remaining.

The only population of both *T. granifera* and *M. tuberculatus* within the zoo is in a small pool used to raise aquatic plants for the zoo. This pool is

devoid of waterfowl but does have a few crayfish and goldfish. Apparently the eating habits of the large number of waterfowl within other areas of the zoo have restricted the snails within the zoo to the one pool. On the basis of infected snails of both species obtained from the plant pool and on the basis of the knowledge of infected snails in the northern effluent, we were able to localize the adult trematode infection to 12 waterfowl pens through which the water was traveling.

Fifty random lots of fecal samples from the 12 pens were examined and found negative for trematode eggs. However, ducks from these pens were autopsied and found to harbor a trematode on the nictitating membrane of the eye. No other adult trematodes were recovered from the ducks.

The unusual shape of the metacercariae of this fluke and the occurrence of the adult fluke in the eye of ducks indicate that the trematode is in the family Philophthalmidae. In order to verify that the fluke recovered from the eyes of ducks was of the same species as the rediae occurring in the snails, cercariae were hatched from *T. granifera* and allowed to form metacercariae. These metacercariae were introduced in three ways to six chickens one day old. Metacercariae were placed directly in the eyes of two chickens, into the nasolacrimal ducts of two chickens, and in the oral cavities of two chickens. The chickens were autopsied 30 days after infection, and adult flukes were recovered from the eyes of all chickens.

It is concluded that the adult trematode existing in waterfowl within the northern part of the San Antonio Zoo and the rediae found in *T. granifera* and *M. tuberculatus* within and immediately outside the zoo are of the family Philophthalmidae, genus *Philophthalmus.* The species is not yet determined because properly stained and mounted adult specimens have not been processed.

We are aware of no human having been infected by a philophthalmid in the U.S. There are, however, at least three human cases of philophthalmids in other areas of the world, mainly Asia. Inasmuch as this trematode cycle is occurring in a city park visited by thousands weekly, efforts will be undertaken to control or eradicate this trematode cycle.

THE PLEUROCERID FAUNA OF THE TENNESSEE RIVER GASTROPODA: PROSOBRANCHIA

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The snails of the family Pleuroceridae in the Tennessee River system have been the subject of extensive collecting and study since pre-Civil War days. Effects of sewage, industrial wastes, siltation, and impoundment have considerably altered the fauna of the Tennessee River System since the time

[1] Most of the collections were made under the auspices of the Tennessee Department of Public Health.

of these investigations. Later studies (1900 to 1940 ca) made by Ortmann, Adams, Goodrich, Van der Schalie, and Clench demonstrated changes in the fauna. However, later changes have followed impoundment and industrialization.

The present study is based on samples from over twenty stations on the river from Paducah to Knoxville from 1956 to 1966. Both hand picked and Petersen grab samples were utilized. Wading and hand picking when the reservoirs were being lowered in the fall, was productive. Samples from Indian kitchen-middens were also examined for species comparison. For convenience the river is divided into three sections: the lower northward flowing section (Kentucky Reservoir); the middle and westward flowing section (Pickwick, Wilson, Wheeler, and Guntersville Reservoirs); the upper and southwestward flowing section (Nickajack, Chickamauga, Watts Bar, and Fort Loudoun Reservoirs). The river is 652 miles in length from the junction of the French Broad and Holston at Knoxville to the Ohio River at Paducah, Kentucky. The only remaining unimpounded section of twenty-two miles is below Kentucky Dam, although this tailwater area is occasionally subject to flow reversal patterns from the Ohio River.

The original fauna of seven species (five genera) has been reduced to only three. These seven are:

1. *Pleurocera canaliculata* (Say) 1821. Contrary to several published reports, this species is still present on the lower Tennessee. It is a dominant form found throughout the entire reach.
2. *Pleurocera alveare* (Conrad) 1854. This species is recorded only from the middle section, Muscle Shoals area, by Goodrich. It apparently did not survive impoundment.
3. *Lithasia armigera* (Say) 1821. Originally found in the middle and lower sections and now apparently restricted to the tailwater of Kentucky Dam.
4. *Lithasia verrucosa* (Rafinesque) 1820. This species once inhabited the entire reach but is now found sporadically in the tailwaters of Kentucky and Pickwick Reservoirs.
5. *Anculosa praerosa* (Say) 1824. This species once occurred throughout the entire reach but is no longer represented by recent records.
6. *Nitocris virgata* (Lea) 1841. This species once was found throughout the eastern section and the upper part of the middle section. It is apparently no longer present.
7. *Io fluvialis* (Say) 1825. This species was originally found in the upper section but is no longer present.

In the upper section all seven species (except *P. alveare*) were once common. Recent records reveal only *P. canaliculata* remaining. The middle section once had populations of all seven species; however, *I. fluvialis* and *N. virgata* were limited to the uppermost area of this section. *P. canaliculata* apparently is the lone remnant of the original fauna of this middle section. The lower section of the river (Kentucky Reservoir) had fewer species (four) represented in pre-impoundment years. *P. canaliculata* is now dominant and found all the way downstream, along with *L. armigera* and *L. verrucosa*. The former distribution of *A. praerosa* in this lower section is not clear, however

it is not represented in recent samples. This absence cannot be attributed to pollution, including siltation.

Extensive sampling in Kentucky Lake and Pickwick tailwaters in 1959 and in 1960 revealed only populations of *L. verrucosa.* The discharge by Pickwick (Big Bend Shoals) is located at this point. Further downstream where the current is less turbulent *P. canaliculata* populations were numerous. At the Perryville Bridge (Decatur Co., Tennessee) large numbers were found on the rocks in shallow water. At Trotters Ferry Landing (Benton Co., Tennessee) this same species was found in abundance in the shallow margins on rocks and clay flats. In fact *P. canaliculata* and the exotic clam (*Corbicula manilensis* Philippi) were the dominant invertebrate species at this particular location. This same situation prevailed on the marginal rock rip-rap on Wheeler Reservoir at Decatur, Alabama, according to Billy Isom (personal communication).

On large tributary streams of the Tennessee River, *P. canaliculata* and *L. verrucosa* were found to be the most resistant species of pleurocerids to a variety of pollutants including siltation. The few shoal areas below the mainstream TVA reservoirs could possibly have remaining populations of the latter. These same tailwaters also harbor remnant populations of commercial mussel species.

A PRELIMINARY REVISION OF THE LAND SNAIL GENUS *RABDOTUS IN TEXAS*

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Six species of *Rabdotus* are known to occur in Texas: *R. dealbatus, R. mooreanus, R. alternatus, R. schiedeanus, R. pilsbryi,* and *R. pasonis.*

Three subspecies of *R. dealbatus* occur in the state. *R. d. dealbatus* (Say) occurs in the Austroriparian, Texan, and Balconian biotic provinces of Blair (1950) and in the Neucian district of the Tamaulipan province. *R. d. ragsdalei* (Pilsbry) occupies the southern part of the Kansan, the westernmost Balconian, and the eastern Chihuahuan biotic provinces. *R. d. neomexicanus* (Pilsbry) occurs in the Guadalupe Mountains of Texas and New Mexico and in the Sacramento and San Andreas ranges of New Mexico, all in the Navahonian biotic province.

R. mooreanus (Pfr.) occurs in the Texan, Balconian, northernmost Tamaulipan and eastern Chihuahuan biotic provinces. Intraspecific variation appears to be clinal and the nominal subspecies *R. m. mooreanus* and *R. m. pecosensis* are not worthy of nomenclatural recognition. *R. mooreanus* forms local hybrid swarms with *R. dealbatus,* but there apparently is little introgression between the two breeding systems.

R. alternatus is highly variable, and the variation is little known and poorly analyzed. However, the species may tentatively be divided into an eastern subspecies, *R. a. alternatus* (Say), which occupies the Tamaulipan province, and a western, Chihuahuan subspecies, *R. a. hesperius* (Pilsbry and Ferriss).

R. schiedeanus (Pfr.) occurs with *R. a. hesperius* in a fossil deposit near Terlingua from which only a single hybrid shell is known (Hubricht, 1960 and in litt.). Living populations of the same region, however, are hybrid swarms. It is thought that deterioration of previously distinct adaptive niches at this northern limit of the *R. schiedeanus* range led to the removal of a selective disadvantage formerly operating against hybrids. In Texas *R. schiedeanus* genes are present only in populations of the southwestern Big Bend region. In Mexico the two species remain distinct.

R. pilsbryi (Ferriss) is a member of the subgenus *Hannarabdotus* Emerson & Jacobson, 1964. At present it is known only from localities within 20 miles west of the type locality, Sanderson, Texas, but undescribed related forms were found in the Chihuahuan desert of Durango and Chihuahua during August of 1968.

R. pasonis (Pilsbry) occurs in arid mountain ranges of the western Transpecos region of Texas and adjacent New Mexico. A related, possibly identical, species, *R. durangoensis* (von Martens), has been described from Lerdo, Durango.

Key to Texas Species of *Rabdotus*

1a. Small species, less than 30 mm long or if longer then not from the Tamaulipan or Chihuahuan biotic provinces 4
1b. Larger, most specimens over 30 mm long, if smaller then usually with a columellar tooth or swelling 2
2a. Spire short, barely equal to body whorl; width equals or exceeds ½ of length, white, without markings .... *R. schiedeanus* (Hybridizes with 3b).
2b. Spire usually longer than body whorl, or if not, then a Tamaulipan province form; width usually less than ½ the height or else Tamaulipan; brown markings usually present on at least some of a population. *R. alternatus* 3
3a. Ragged brown streaks usually present on at least some individuals of a population; spire not much longer than body whorl, outline oval; columellar tooth or swelling often present .... *R. a. alternatus*
3b. Ragged brown streaks never present, smooth-edged ochre streaks usually never present on some individuals of a population; spire conspicuously longer than body whorl, outline conic; no trace of a columellar tooth .... *R. a. hesperius*
4a. Lip of adults broadly expanded, outline of shell before expansion fusiform; markings of smooth to ragged brown streaks; surface glossy .... *R. pilsbryi*
4b. Not as above 5
5a. Shell length 16 mm or less; markings ragged brown streaks on cinnamon ground; arid mountain ranges of western Trans-pecos region .... *R. pasonis*
5b. Shell length more than 18 mm or else not from western Transpecos .. 6
6a. White, without ragged color streaks, or rarely a few streaks on the spire, base may be light buff .... *R. mooreanus*
6b. Pattern of ragged streaks on a light ground or if plain then conspicuously rib-striate. *R. dealbatus* 7
7a. Area of ground much exceeds ragged streaks or occasionally without markings; outline relatively more slender; shell conspicuously rib-striate .... *R. d. ragsdalei*

7b. Ragged streaks nearly equal to exceeding area of ground; shell relatively wider; shell smooth 8
8a. Shell less than 30 mm long, usually less than 26 mm; eastern .... *R. d. dealbatus*
8b. Shell usually over 30 mm tall; mountains of southern New Mexico and adjacent Texas .... *R. d. neomexicanus*

All of the taxa treated here are described in detail in Pilsbry (ANSP Monogr. 3, 2(1): 1–21, 1946) except *R. schiedeanus,* his treatment of which actually applies to *R. a. hesperius.* The right-hand specimen in his figure 7a is *R. schiedeanus.*

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SOME RESEARCH NEEDS AND METHODS FOR PROTECTING NAIADS FROM EXTINCTION

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Last year at Corpus Christi, Dr. Stansbery described the dwindling numbers and extinction of one to two dozen naiad species. There is a need for considerable effort to reverse this trend. I would like to describe some needs and methods I am aware of and some of my own experimental findings. One of the most important needs is documentation of existing populations so that legal evidence is available next year or ten years from now of "what was there" where pollution is serious but not yet entirely irreversible. It is also important that shell clubers let their feelings be known about the loss of these exotic animals. Another point that should be kept in mind is that the freshwater mussels not only have intrinsic value but also a significant and increasing commercial importance. One of the best descriptions of this that I have seen is the paper by A. C. Lopinot on the Illinois Mussel published in Outdoor Illinois Magazine, May, 1967. The shells are sold for as much as five hundred dollars a ton to Japan and are necessary as nuclei for cultured pearls which form about a third of Japan's marine trade. One may also buy pearl buttons from almost any American department store.

In my own capacity at the National Water Quality Laboratory at Duluth, Minnesota I have devoted most of my efforts to the freshwater mussel. My objective is to find out how much oxygen is required and how much copper and other toxicants are harmful for the ultimate survival of naiad species. Specifically this means finding the parts per million by weight that prevent survival, growth, and reproduction for all life stages. Some of my findings so far are that adult riffle species require 2½ ppm of oxygen over the 10

week period in the summer when oxygen is normally lowest and die in 25 ppb of copper in about that period of time. Data such as this is used by organizations establishing standards of maximal allowable concentrations of toxicants. If mussels follow the pattern of other organisms, growth of juveniles and reproduction of adults will be more sensitive parameters than survival and these results should be used for establishing standards. In a few species, however, it has happened that the animals grow and reproduce up to the time of death but eventually do die.

In order to study the effect of toxicants on growth of juvenile mussels it was first necessary to learn how to grow them in the laboratory. I found no method described in the literature and have spent many months on this problem. A method was finally worked out by my technician Miss Margaret Paige. The method was to add glencoe starter granules of trout fry food from Glencoe Mills, Inc., Glencoe, Minnesota.* One-half gram was added every Monday, Wednesday, and Friday and was forced through a tube to settle at one corner of a 6 gallon aquarium. The clams were in a finger bowl in the center of the aquarium and the drain was at the other end. Water was continuously dripping in at the feeding end of the aquarium at such a rate that the aquarium initially took eight hours to fill up. Five sphaeriid clams each grew 0.9 to 1.1 mm in three weeks in this system.

In addition, it may well be that some of the most significant toxicants are not yet under consideration. Koshtoyants and Salánki (1958) found that addition of 10^{-3}M KCl (39 ppm K) exceedingly altered the normal behavior of *Anodonta cygnea.* This concentration is not considerably greater than that found in some rivers. Mortality was not reported but their studies were only one week in duration so I conducted a preliminary exposure of 30.1 ppm K in the form of KCl to see if there was any effect over a longer exposure period at the highest concentration of potassium one could expect to find naturally. Slide 7 shows that no clams died in the first 17 days of exposure but then more than half died in the next 15 days. These were 4 *Lampsilis* out of 8, and 5 *Fusconaia flava* out of 8.

Final experiments were performed with six concentrations including a control. Ten specimens of *Lampsilis siliquoidea* and *Actinonaias ligamentina* from Yellow River were placed in each concentration. 90% of these clams were wiped out at 11 ppm K. A slightly delayed but similar rate of kill occurred with *Amblema costata* and *Fusconaia flava.* From extrapolation of these curves and from the fact that Lábos and Salánki (1963) found *Anodonta* glochidia to react abnormally to as little as 3.9 ppm K, I predicted that streams in the USA with more than 7 ppm K would have no mussels, those with less than 4 ppm would have mussels and 4–7 would be considered marginal. Dr. van der Schalie's map published in 1950 shows that mussels are generally found only in the predicted areas. Dr. Stansbery has communicated to me that none of the six streams containing more than 7 ppm K was known to have mussels. Of the streams with less than 4 ppm K, Dr. Stansbery was unsure of two rivers but for the others, 28 of 39 were known to have mussels.

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* Mention of commercial products does not constitute endorsement by the Federal Water Pollution Control Administration of the United States Department of the Interior.

In the marginal category (4–7 ppm K) only 2 of the 10 rivers were known to have mussels.

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SCANDALS IN MALACOLOGY

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ABSTRACT

A short list of events in the history of malacology which might be called scandalous were cited. These included such things as authors engaging in unethical practices to gain credit for describing a new species of shell before another writer does so; the proliferation of naming species and genera apparently with the only purpose of seeing the describer's name in print; the sharp business practices of some shell dealers in the past to separate the collector from his money; and finally the scandalous misinformation regarding mollusks which appears regularly in the media of public information.

SOME POSSIBLE CONSEQUENCES OF A SEA-LEVEL PANAMA CANAL

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(SUMMARY)

1. The proposed sea-level canal across Central America may breach the present faunal barrier and permit the Caribbean and Panamic-Pacific molluscan faunas to intermingle.
2. Rubinoff (1968) believes that this will provide opportunities for conducting a great biological experiment and pleads for more study of the faunas so that the effects of mixing may be recognized. Briggs (1969) deplores the prospect of faunal mixing and believes that mass extinction of hundreds or even thousands of species, especially on the Pacific side, will probably result.
3. Accurate forecasts of malacological effects are impossible because the mollusk faunas living at 100 fathoms or less are too large (totaling about 5000 species) and too little is known about the life histories of the species involved. Some estimates of gross effects are nevertheless possible.
4. There are striking differences in the ecologies and in the mollusk faunas of these regions. As pointed out by Rubinoff (1968) coral reefs are absent on the Pacific coast, tidal fluctuations average about 20 feet, and offshore upwelling periodically lowers surface water temperatures by up to 32°F.

Coral reefs abound on the Caribbean coast, tidal fluctuations average one foot, and annual variation in surface water temperature is only about 10°F.

5. Despite the seemingly more rigorous ecology, the fauna near the Pacific end of the Panama Canal is much more populous and diverse than the fauna near the Caribbean end. If a sea-level canal is built in that region, probably more species will migrate initially from the Pacific to the Caribbean than vice-versa. According to the literature, the Panamic-Pacific molluscan fauna as a whole is also more diverse than the Caribbean fauna. Lists of the dominant epifaunal species observed near both ends of the Panama Canal and dominant families in the Panamic-Pacific and Caribbean are given.
6. Chesher (1968) and Menzies (1968) have shown that opportunities now exist for passage of some marine invertebrates through the canal both as larvae in ballast water or as adults attached to ships' hulls. Such transport appears to have been either (a) ineffective in establishing immigrant species in the other ocean or (b) unrecognized because so many species in each ocean are morphologically similar to, and perhaps capable of hybridizing with, analagous species in the other ocean.
7. Probable effects of reciprocal faunal migration are multiple and include the following: (a) failure to colonize the other ocean because the ecology is inimical or for other reasons, (b) successful insertion into the other fauna without affecting the residual abundance or composition of that fauna, (c) successful insertion followed by reduction in the abundance of some native species, (d) successful insertion followed by extinction of some native species. Since (c) and (d) may occur in part, safeguards against faunal interchange are necessary.
8. Briggs (1968) has discussed the widespread Pliocene and Pleistocene extinction of the unique South American marsupial mammal fauna which followed the invasion of South America by fifteen families of North American placental mammals by way of the newly-elevated Central American land bridge. He has cited this disaster as a parallel to what is likely to happen, especially to the Panamic-Pacific fauna, if the two marine faunas are allowed free contact through a sea-level Panama Canal. The analogy is inappropriate, however, at least as applied to mollusks. The mammal faunas were almost completely different at the ordinal level and the North American fauna contained efficient predators (cats, dogs, weasels, etc.) against which much of the South American fauna had no defense. The marine mollusk faunas differ principally only at the species level and in part at the generic level. Neither fauna contains new kinds of molluscan (or fish) predators for which the other is unprepared. Some extinctions may result from free interchange but the effect is likely to be not nearly as drastic as that forecast by Briggs.

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SEASONAL VARIATION IN GONAD ACTIVITY IN FRESHWATER MUSSELS, AND ITS SYSTEMATIC SIGNIFICANCE

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Abstract

Seven species of naiads (viz., *Anodonta gibbosa, A. peggyae, Carunculina paula, Ellipto strigosus, Quincuncina burkei, Villosa lienosa* and *V. vibex*) were collected from the same locality in northwestern Florida at monthly intervals over one calendar year. Histological examination of the gonads of the animals was made, and notes were taken on the size/age of the animals and the periods of gravidity.

Observations on the condition of the gonads of each sex in each species for all collections made it possible to plot the gonad activities on a seasonal basis. The seasonal gonad activities of males and females were divided into four stages, each characterized by a predominant feature: 1. mature gametes; 2. spermatogenesis in males, many ova and some nutrient matter in females; 3. sperm morulae in males, oögenesis and much nutrient matter in females; and 4. spent/inactive phases.

The gonad activities of *A. gibbosa, E. strigosus, Q. burkei, V. lienosa* and *V. vibex* are highly seasonal, the sequence of stages being 4-3-2-1 in both sexes. Periods of peak quantities of mature gametes occur just prior to the appearance of ova and subsequent early embryos in the marsupial demibranchs, regardless of whether the duration of incubation is short (i.e., tachytictic, in *E. strigosus* and *Q. burkei*; *A. gibbosa*?) or long (i.e., bradytictic, in *V. lienosa* and *V. vibex*). Non-seasonal gonad activities (mature ova and spermatozoa occur throughout the year) appear in *A. peggyae* and *C. paula* (both bradytictic). Some variation in the gonad activity of male *A. peggyae* and female *V. vibex* was found in animals of different age classes in the same collection. However, there was found no such variation in performance in female *A. peggyae* and male *V. vibex* of different age classes, and the activity of males and females of *C. paula, E. strigosus, Q. burkei* and *V. lienosa* was consistent among different-sized animals.

Males are more useful than females in defining seasonal gonad activity, partially due to the temporary presence of sperm morulae. These peculiar bodies, usually termed inclusions, have been suggested to undergo catabolism to provide nutrient molecules for the subsequent typical spermatogenesis. Some morulae, however, have been reported to transform into mature spermatozoa. Unfortunately, information on the origin, structure and function(s) of sperm morulae remains fragmentary and largely hypothetical.

Both seasonal and non-seasonal gonad activities appear in representatives of different subfamilies of the Unionidae (even within a single genus), and they also are independent of the duration of glochidial incubation. Consequently, it is concluded that these glandular behaviors are species-specific adaptations.

THE SHELLS OF DIOSCORIDES OF ANAZARBA

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One of the great herbalists of classical times was Dioscorides. Born in Anazarba near Tarsus in Asia Minor, he travelled widely in the Roman Empire. The author of the celebrated herbal, *De Materia Medica,* he flourished about the middle of the 1st century, probably during the reign of Nero, to whom he dedicated his famous work (Sarton, 1945). The treatise consists of 5 separate books, and the first 74 chapters or short entries of Book II discuss animals and their uses. Mollusks are mentioned in at least 7 chapters.

The writings of Dioscorides were considered authoritative almost until the era of Linnaeus. Greek was the language used by him, and a Byzantine illuminated manuscript of the sixth century, produced for Juliana Anicia, the daughter of Emperor Olybrius, is the earliest extent textual source (Singer, 1921). Several manuscripts in Greek, Arabic or Latin are known (Thorndike, 1933), and after the invention of printing, editions in Italian, French, German, and Spanish appeared. Dubler (1953) discussed the 16th century editions and reproduced the Spanish text of Andrés de Laguna. The colored woodcuts illustrating this lecture were taken from Mattioli's Lyon edition of 1572.

Most of the mollusks mentioned by Dioscorides come from the Mediterranean Sea and adjacent areas; the Renaissance texts provide their names in classical and vulgate languages, a forerunner to our present day synonymies. Perhaps the most famous species is *Murex brandaris,* the purple murex used by the ancients to prepare dyes. After being burned and processed, the shell was employed by some for brushing teeth or drawing boils. Similar curative qualities were ascribed to special concoctions which utilized the so-called "ionia" or columella of various snails. Another well-known species is *Mytilus edulis,* fine for the table but better, after proper preparation, for afflictions of the eyes and occasional bites of dogs.

The name *Tellina* was introduced by Dioscorides who also described their delicious flavor and suggested that their broth was especially wholesome. Tellin shells burned and mixed with salt and cedar oil, can be applied to the eyelids to prevent the growth of lashes. *Donax trunculus,* which is widely esteemed in the Mediterranean for its tastiness, is probably the species figured by Mattioli. Dioscorides' use of the term *Chama* evidently referred to *Cardita* and *Cardium*; species of these genera are recommended for the making of soup.

The onyx, unguis odoratus, or olorosa appears to have been the operculum of a freshwater snail, possibly *Pila* or *Thiara* (van Benthem Jutting, 1959) which lives according to Dioscorides in association with nard, an Indian plant used in Oriental perfumery. After heating, the olorosa has a sweet smell, which when inhaled suffices to cure female diseases. In discussing the *kochlias,* Dioscorides may be accredited with having differentiated between land, freshwater and marine snails (Locard, 1884). He recommended the earth snails of Sardinia and other islands in the Mediterranean for saving

hair and healing wounds. The sea hare, *Aplysia*, is praised as a depilatory. The illustrations of medieval texts show helicids, muricids, cypraeids and other gastropods.

The cuttlefish *Sepia officinalis* has several medicinal uses. Its ink supposedly aids in digestion while the cuttle, being prepared, is good for cleansing teeth or curing diseases of the eyes in cattle.

Since Linnaeus and other 18th century natural historians relied on many of the medieval and Renaissance texts, which were in essence commentaries on the naturalists of classical times, some of our current nomenclature had its origin over 2000 years ago. Dioscorides is but one example of this historical continuum and the survival of terms used by him in the 1st millenium of our era attests to the antiquity and continuity of the natural sciences.

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SNAIL CONTROL PROBLEMS IN HAWAII

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The enumeration of snail control problems in Hawaii has been explicitly discussed in a paper with the title: "Man Meddles with Nature—Hawaiian Style." More detailed information, as given at the recent meetings with the use of kodachrome slides, will appear in the November issue of *The Biologist*. However, snail control in Hawaii has now reached a very complicated and involved state. Several agencies have been at work with little or no contact among them. It is especially unfortunate because with the world renowned Bishop Museum there and its very capable malacologist, Dr. Yoshio Kondo, some of the serious and unfortunate introductions might well have been prevented.

The Giant African Snail (*Achatina fulica* Bowdich) was introduced into Maui, Hawaii from Formosa in 1936 and sold there as "materia medica"; it was taken from Japan and put into a garden in Oahu in 1938 for aesthetic purposes. These snails have now become widely distributed and have been a problem to agriculture. Under the auspices of agricultural interests an attempt was made to find carnivorous snails which would keep the colonies

[1] This investigation was sponsored in part by the U.S. Commission on parasitic Diseases, Armed Forces Epidemiological Board on Grant DA 49 193 Md 2651.

of the Giant African Snail in check. Of the many introduced land snails that were tested, *Gonaxis* from East Africa and *Euglandina* from Florida were considered most promising. It appears that at present there is little basic information that would prove the efficacy of *Gonaxis* in the control of *Achatina* in Hawaii. As for *Euglandina,* the introduction appears especially serious in that these animals appear to have moved far beyond the territory of *Achatina* which are found mainly in the lower, limestone regions. *Euglandina* now has invaded the mountain regions where they pose a dangerous threat to the fabulous endemic land snail fauna of that region!

More recently the Giant African Snail problem has been compounded by the appearance of the Rat Lung Worm (*Angiostrongylus cantonensis*) in Hawaii. This nematode uses a wide variety of land snails (many of which are introduced species) but *Achatina* is among its chief carriers. The snails become infected when they feed on rat feces. Humans eating partially cooked or raw snails ingest the infective larvae which pass through the human brain en route to the lungs. It is becoming a serious public health problem; in Formosa some thousand cases of brain damage due to ingesting larvae of the Rat Lung Worm are recorded. While *Angiostrongylus* infections probably kill heavily infected rats, the snails obviously serve as an important rat food.

Hawaii has some of the largest cattle ranches in the world; the cattle also are infested with fascioliasis. To control the acquatic snails (*Lymnaeidae*) three species of sciomyzid flies have been cultured and are being released to serve as biological controls. To date little is known as to how effective this fly control program is. However, observations made on endemic lymnaeids (such as the sinistral *Lymnaea reticulata*) suggest that their ecology might be more suitable for the sciomyzid flies than the snails they are supposed to eliminate. Again a threat is posed with the introduced sciomyzids creating a possible hazard to the endemic fauna.

Swimmers' itch (Schistosome dermatitis) also occurs in Hawaii. The intermediate host is a marine snail, *Littorina pintado,* and the definitive host is the ruddy turnstone. It has fortunately been confined to a small island along the coast, although the intermediate host has a wide range along the shores. It has not appeared to be a tourist problem although the potential is there.

SOME BASIC PROBLEMS IN NAIAD TAXONOMY. David H. Stansbery, Ohio State University, Columbus, Ohio.

(no abstract submitted)

SPECIAL INVERTEBRATE STAIN TECHNIQUES

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Summary

Many histologic techniques are available for staining normal and abnormal vertebrate tissues. Only a few, however, have been applied to invertebrate

tissues. Research on mortalities of commercially important bivalves (oysters, clams, and mussels) in the past few years has intensified the need to apply existing techniques to invertebrate histology. The techniques chosen serve in the diagnosis of disease entities and in the recognition and provision of meaningful interpretations of pathological conditions.

Selection of special stains for invertebrate tissues is based on three factors: 1) ability to be modified for invertebrate research methods; 2) applicability to special invertebrate pathologic problems; and 3) preference of the pathologists. Three techniques—Ziehl-Neelsen carbol fuchsin, periodic acid-silver methenamine, and Feulgen triple stain—have been selected and used routinely for bivalve tissues by the histology group of the Bureau of Commercial Fisheries Biological Laboratory at Oxford, Maryland.

Originally the Ziehl-Neelsen carbol fuchsin technique was modified to answer the question whether haplosporidan parasites causing mortalities in the oyster, *Crassostrea virginica*, produced spores with acid-fast properties.

After treatment of stained infected oyster tissue with an acid solution, acid-fastness was demonstrated in the sporoplasm of mature spores, but not in the spore wall or host tissue. Details of host tissues were elucidated by counterstaining with the Harris hematoxylin and eosin technique used as a routine diagnostic procedure. Plasmodial stages of these haplosporidan parasites exhibit strong basophilia and therefore stain intensely with the hematoxylin. These combined techniques yield: blue nuclei; pink cytoplasm; blue basophilic substances; and red acid-fast substances.

Extensive routine surveys have been made of natural oyster bars for the presence and distribution of these haplosporidan parasites. The acid-fast technique incorporated with Harris hematoxylin and eosin counterstain proved useful as a quick and efficient method of locating spores and plasmodia in bivalve tissue sections.

Periodic acid-silver methenamine stain has recently been used to demonstrate *Labyrinthomyxa marina* in oyster tissue sections. This fungus is parasitic, and causes high mortalities in oysters on the Gulf and South Atlantic Coasts of the United States. Histological detection of light infections of this parasite in sections of oyster tissue requires skill and time. The fresh culture technique is the most reliable diagnostic method. However, a practical histologic technique which yields conspicuous, readily identifiable parasites and elucidates host tissue would be of great value.

Silver methenamine facilitates detection because it stains the cell wall of the parasite black, yielding a very conspicuous parasite in sectioned host tissue. This method is not considered to be a conventional silver reduction technique, but rather a histochemical demonstration of neutral mucopolysaccharides and fungal walls. Any number of counterstains can be employed without obscuring the detail of the parasite. This feature is of extreme importance when the relationship between the parasite and host tissue response is to be made. For our routine screening, Harris hematoxylin and eosin is used as a counterstain. Therefore stained material appears as follows: nuclei—blue; cytoplasm—pink; pigment cells—brown to black; basement membranes—deep rose; and fungus cell wall—black.

The Feulgen triple stain has been effectively used as a routine, diagnostic, yet specific stain and is easily adapted to invertebrate tissues. It incorporates

the demonstration of DNA by the Feulgen reaction with the picro-methyl blue differential connective tissue stain. Clarity of cellular structure of normal tissue is improved by the combined differential stains. The host response to a pathologic condition and nuclear structure in strongly basophilic protistan parasites is greatly enhanced. Chromatin and other aggregates of DNA, such as sperm heads, stain magenta; nuclei and basophilic substances stain yellow; muscle, cytoplasm, and eggs are varying shades of yellowish green; and connective tissue, basement membrane, and sperm tails are blue to green.

SPECIATION AND DISTRIBUTION OF ARCTIC WEDGE CLAMS (*MESODESMA*) IN THE WESTERN NORTH ATLANTIC

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Two species of bivalve mollusks of the genus *Mesodesma* are found in the western North Atlantic: *M. deauratum* (Turton), 1822, the northern form, and *M. arctatum* (Conrad), 1831, the southern form. Although the two species were described many years ago, there has always been considerable doubt whether the separation is a valid one, and there has been little detailed information regarding their distribution. The purpose of this study has been to resolve the speciation question and possibly provide more information on distribution.

The search for abundant, easily-reached populations was initiated in 1962 as part of doctoral studies at the University of New Hampshire. It soon became clear that distribution was discontinuous and that many of the important collecting sites were relatively inaccessible. Extensive collecting and careful study of museum collections indicated that neither species currently extends south of northern New Jersey or north of Belle Isle Strait between Newfoundland and Labrador. Fossil and subfossil material indicate that the geographical range extended further north and south at various times in the past.

The extensive collecting program also revealed that significant, dense populations are restricted almost entirely to well-sorted sand areas adjacent to river mouths and tidal inlets. To date, extensive living populations have been found and studied at Nauset Inlet, Cape Cod, Massachusetts; Plum Island, Massachusetts; Dominion, Cape Breton Island, Nova Scotia; Basin Head, Prince Edward Island; Shippegan Channel, Baie de Chaleur, New Brunswick; Newport, Gaspé Sud, Québec; Chandler, Gaspé Sud, Québec; Cape Bon Ami, Gaspé, Québec; Rivière à Claude, Gaspé, Québec; Petite Matane, Québec; St. Ulric, Québec; Godbout, Québec; Point Moisie—Matamek, Québec; and Western Brook, Newfoundland. Some other sites have yielded living specimens but not in sufficient abundance to permit sampling for statistical study. In addition, one very abundant Pleistocene site at Cumberland, Maine, has been studied.

Justification for the original separation into and recognition of two species

is based on apparent differences in truncation of the posterior valve margin. *M. arctatum,* usually taken at New England sites, appears to have a sharply truncate posterior margin. *M. deauratum,* most often taken in Canadian waters, seems somewhat less truncate posteriorly.

Careful comparative studies of soft-part anatomy using specimens from various localities showed no measurable differences. Variable degrees of truncation were detectable, however, and methods were devised to subject this possible distinction to statistical analysis. Computer studies of length/width ratios and length/height ratios produced no significant results, but analysis of length/truncation differences appear to be significant in preliminary studies. Truncation was measured by dropping a vertical from the umbo and measuring the extent to which each valve extended posteriorly beyond the vertical. Computer plotting of length/P-value (truncation) by regression analysis shows substantially different placement for populations north of Cape Bon Ami (*M. deauratum*). There is one exception: The population at Western Brook, Newfoundland (somewhat further north but much further east of Cape Bon Ami), exhibits a regression analysis pattern similar to the more southern populations (*M. arctatum*). The Pleistocene "population" at Cumberland, Maine, also fits the regression analysis pattern of the southern form. As described by Davis (1967, Proc. Nat. Shellf. Assoc. *57*: 67), the northern form, *M. deauratum,* is commonly infested with the boring polychaete *Polydora websteri* Hartman 1943. No evidence of this infestation has been found in living or recent specimens of *M. arctatum* south of Cape Bon Ami. Evidence of *Polydora* infestation is occasionally found in the Pleistocene specimens uncovered at Cumberland, Maine. The Cumberland material has been carbon-dated at 12,000 ± 270 years B. P., when conditions were considerably colder than at the present on the coast of Maine. The fossil specimens, however, are somewhat smaller, on the average, than living specimens found in New England today. Size comparison among all populations sampled reveals a gradual decrease in size range for each more northerly sample of *M. arctatum* until Cape Bon Ami is reached. North of Cape Bon Ami, where *M. deauratum* appears to reside, a much larger size range is immediately apparent. It is questionable, however, that any such size variation can be directly linked exclusively to water temperature variation as the Western Brook sample exhibits a size range comparable to that of Cape Cod.

Although studies at this point must still be considered preliminary, it is tentatively concluded that *M. deauratum* and *M. arctatum* are, indeed, valid species. It is also concluded that *M. deauratum* is restricted to the waters of the St. Lawrence Estuary with the boundary between the two species extending from near Cape Bon Ami on the south to some point west of Belle Isle on the north. It is further concluded that some combination of ecological factors permits *Polydora websteri* infestation of *M. deauratum* in the St. Lawrence Estuary but not *M. arctatum* outside the Estuary (although *P. websteri* is present throughout the range of both species). Perhaps the ecological combination of factors did exist in the Gulf of Maine 12,000 years ago when *M. arctatum* was infested. Such conditions did not, however, alter the length/truncation ratio of the species.

STUDIES OF THE STRUCTURE AND ULTRASTRUCTURE OF THE GLOCHIDIAL STAGE OF *ACTINONAIAS LIGAMENTINA* LAMARCK (BIVALVIA: UNIONIDAE)

KAREN HEFFELFINGER OLSON
Ohio State University, Columbus, Ohio

Since no previous electron microscope studies are known for the glochidium, it is hoped that this study will at least provide a starting point for further investigations.

The shell of the glochidium was found to be two layers thick with evidence suggesting that it is deposited intermittently, since growth rings were noted on the surface of the shell. The flange was as Arey (1932) depicted it, an inturned shelf with conical teeth over much of the surface. No additional shell material is apparently being secreted at this time.

The presence of microvilli, micropinocytotic and microphagocytotic vesicles over much of the apical cell surfaces of the inner mantle supports the concept of a digestive function for this organ. A variety of cell attachments were represented by the zonula occludens, zonula adhaerens, septate desmosomes, and interdigitations of cell surfaces. Five cell types were identified for the inner mantle, each named for an obvious feature which it displayed. These types are: the granule-containing cells, flattened squamous epithelial cells, ribosome-rich cells, non-ciliated papillae, and ciliated papillae.

The four pairs of papillae, formerly designated in the literature as hairs or bristles, were identified as true cilia with a 9 plus 2 fibril arrangement; thus the name ciliated papillae is here assigned to these structures. No movement of these cilia was observed in living glochidia but a mechanical force applied to them elicited stimulation which was apparently conducted to the adductor muscle causing it to contract. On the basis of the mode of stimulation, the unicellular core of the sensory papillae was classified as a mechanoreceptor.

The very flattened outer mantle lies in close proximity to the interior of the shell. It appears to have a function of providing an anchorage and attachment layer for the inner mantle and the adductor muscle.

Evidence indicates that the adductor muscle of the glochidium is neither smooth nor striated. Nor does it exactly fit into any categories presently used to describe muscle types. Thick and thin filaments are found with the thick ones arranged in a hexagonal pattern to one another. Some properties such as sustained contraction, size of the thick filaments, and the presence of cross-striations of the thick filaments indicated that paramyosin could be a component of this muscle.

The rudimentary sac and lateral pits were identified and examined at the light microscope level. It is believed from these observations that the rudimentary sac opens posteriorly into the mantle cavity in at least some glochidia. Other observations also suggested that this structure could be a rudimentary gut. The lateral pits are not believed to be ciliated as was previously noted in the literature, but perhaps this observation would be valid for other species of glochidia. Further examination must be made of these structures, using the electron microscope, to obtain more information as to the form and function of the rudimentary sac and lateral pits.

SOME TECHNIQUES IN STUDIES OF FRESHWATER SNAILS. Harold J. Walter, Dayton, Ohio.

(read by title)

THE UNIVERSITY OF ARIZONA MARINE SCIENCES PROGRAM[1]

Albert R. Mead
University of Arizona, Tucson, Arizona

Abstract

For the past 11 years, the University of Arizona has been cooperating with the Universidad de Sonora and other Mexican institutions in an extensive program of investigation of the marine resources of the Gulf of California, particularly along the Sonoran and Sinaloan coasts from the Colorado River Delta to Mazatlan. The field headquarters for this program is the Puerto Peñasco Marine Research Station, located 1½ mi. SE of the small fishing port of Puerto Peñasco, Sonora, Mexico. It was built adjacent to the Desalination Plant and Greenhouse Project on 20 hectares of land facing on the Gulf of California. The Station complement consists of three buildings: a central laboratory with a beach-well filtered sea water system, a classroom unit, and a research-residence unit. A 23 ft. LONE STAR cabin cruiser, equipped with wet and dry specimen laboratory facilities and the basic collecting gear, is assigned to the Station. Research and course field trips are conducted at the Station throughout the year. Intensive field instruction is offered during Summer Session for eligible American and Mexican as well as other foreign students. University research projects in progress include floral and faunal surveys of the northern Gulf, factors controlling the distribution of Gulf fishes, physiological ecology of invertebrates and fishes, sedimentology, effect of brine effluents on the marine environment, coastal geology, and the analysis of tides in the northern Gulf. Publications consist of: TIDE CALENDAR FOR THE NORTHERN GULF OF CALIFORNIA (1967+) and GULF OF CALIFORNIA FIELD GUIDE SERIES (1966+).

NOTES ON *VALVATA TRICARINATA* FROM CENTRAL NEBRASKA

Carl W. Gugler
University of Nebraska and University of Nebraska State Museum

Abstract

The distribution of *Valvata tricarinata* (Mesogastropoda: Valvatidae) in the Plains States usually is described as "northern and eastern." Fossil specimens have been considered as indicators of a cool, moist climate and of continuity in aquatic conditions. The only previously published record of occurrence of modern forms in Nebraska is from a spring-fed pond at Valentine, Cherry County, near the South Dakota border.

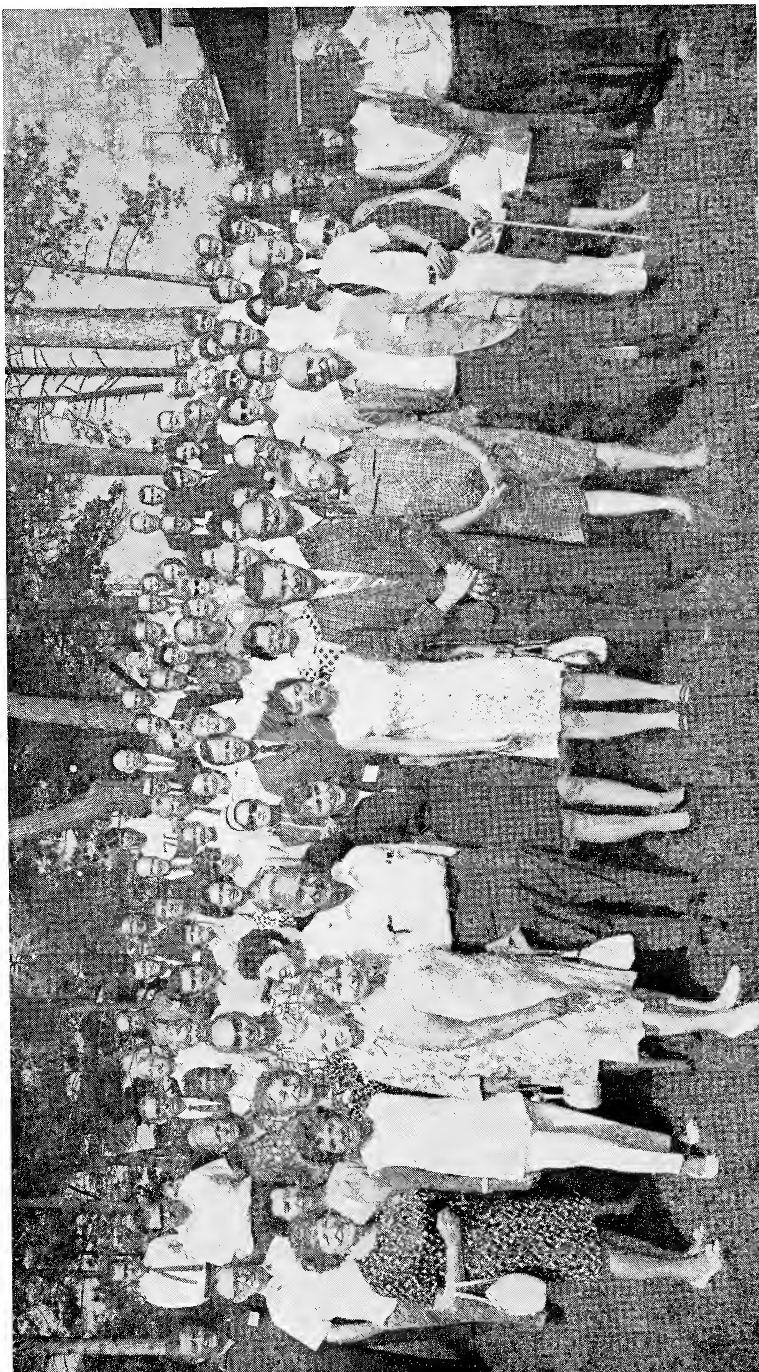
[1] Support for this Program has been from: The Rockefeller Foundation, The Arizona Foundation, Office of Naval Research and the National Science Foundation.

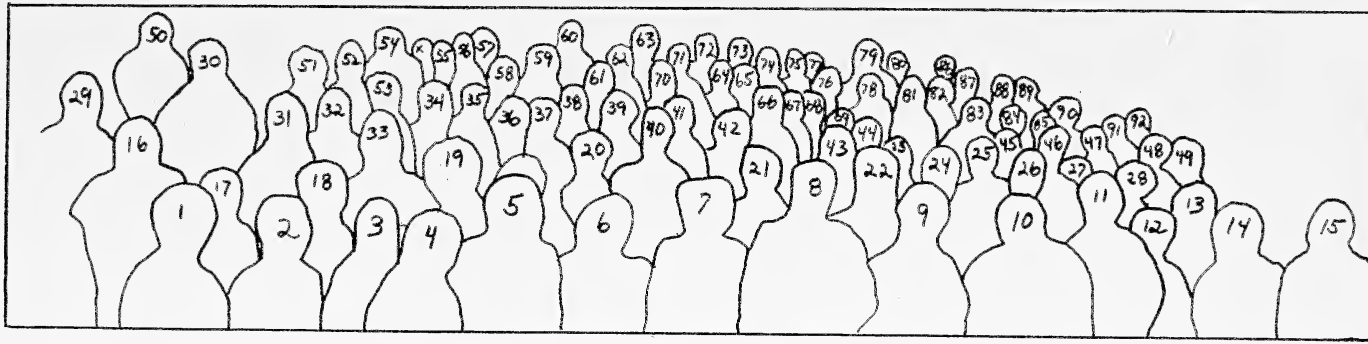
The present report documents the occurrence of *Valvata tricarinata* at Arnold Lake, in Custer County, in the central part of the state. Arnold Lake, a 10 acre spring-fed impoundment, is part of a State Recreational Area. It is drained periodically for fish re-stocking. At the time of an early May collection the snails were beginning their annual cycle of egg deposition. The water temperature was 17°C., the pH was 7.9, and the calcium hardness was 100 mg/1 as $CaCO_3$.

Aspects of habitat and reproductive biology were illustrated.

MEMBERS AND GUESTS ATTENDING THE 35th ANNUAL MEETING:

Herbert and Marjorie Athearn, Cleveland, Tennessee
John M. Bates, Eastern Michigan University, Ann Arbor, Michigan
Dr. C. J. Bayne, Museum of Zoology, University of Michigan
Mr. and Mrs. Fred Berg, Santa Barbara, California
Mr. and Mrs. David Bickel, Ohio State University, Columbus, Ohio
Dr. Kenneth J. Boss, Museum of Comparative Zoology, Harvard University
Lucretia R. Buchanan, Bureau of Commercial Fisheries, Easten, Maryland
Alice and Tom Burke, Chicago Shell Club, Chicago, Illinois
Michael Castagna, Virginia Institute of Marine Science, Wachapreague, Virginia
Mr. and Mrs. Crawford N. Cate, Conchological Club of Southern California, Los Angeles
Dr. and Mrs. Arthur H. Clarke, National Museum of Canada, Ottawa, Ontario, Canada
Dr. and Mrs. William J. Clench, Harvard University, Cambridge, Massachusetts
Dr. James X. Corgan, Austin Peay State University, Clarksville, Tennessee
Mr. and Mrs. Anthony D'Attilio, Laguna Beach, California
Dr. John D. Davis, Smith College, Northampton, Massachusetts
Dr. Charlotte Dawley, North Carolina Shell Club, Greensboro, North Carolina
Sally Dennis, Eastern Michigan University, Ypsilanti, Michigan
Dr. Dolores and Dr. Harold Dundee, Louisiana State University and Tulane University, New Orleans
Dr. William K. Emerson, American Museum of Natural History, New York City
Dr. and Mrs. Lake Fowler, Galveston Shell Club, Galveston, Texas
Dr. Dorothea Franzen, Illinois Wesleyan University, Bloomington, Illinois
Sam D. Freed, New York Shell Club, Hightstown, New Jersey
Inez Gruetzmacher, Menominee, Michigan
Dr. and Mrs. Carl W. Gugler, University of Nebraska, Lincoln, Nebraska
Mrs. Daniel Hagge, Wausau, Wisconsin
Dr. William Heard, Florida State University, Tallahassee, Florida
Marion Schroth-Hubbard, New York Shell Club, Seaford, New York
Dr. and Mrs. Marc J. Imlay, National Water Quality Laboratory, Duluth, Minnesota
Mr. and Mrs. M. Karl Jacobson, New York Shell Club, Rockaway, New York
Dr. and Mrs. Charles E. Jenner, University of North Carolina, Chapel Hill, North Carolina
Mrs. Dorothy M. Kaptur, Chicago Shell Club, Waukegan, Illinois
Mr. and Mrs. Eugene P. Keferl, Ohio State University, Columbus, Ohio
Dr. Louise Russert Kraemer, University of Arkansas, Fayetteville, Arkansas
James J. Landye, Washington State University, Pullman, Washington
Dr. and Mrs. Aurèle LaRocque, Ohio State University, Columbus, Ohio
Mr. and Mrs. Albert Lindar, Chicago Shell Club, Chicago, Illinois
Grace R. MacBride, Philadelphia Shell Club, North Wales, Pennsylvania
Lou Mason, Naples Shell Club, Naples, Florida
Dr. Max R. Matteson, University of Illinois, Urbana, Illinois





AMERICAN MALACOLOGICAL UNION

Thirty-fifth Annual Meeting

1. Grace MacBride; 2. Mrs. Albert Lindar; 3. Hellen Notter; 4. Mrs. Karl Jacobson; 5. Karl Jacobson; 6. Dr. Ruth Turner; 7. Mrs. Joseph Rosewater; 8. Dr. Joseph Rosewater; 9. Margaret Teskey; 10. Dr. William Clench; 11. Dr. Kenneth Boss; 12. Mrs. Harvey Meyer; 13. Herbert Athearn; 14. Marjorie Athearn; 15. Harvey Meyer; 16. Albert Lindar; 17. Mrs. William Starrett; 18. Mrs. Albert Taxson; 19. Dorothy Raeihle; 20. Mrs. Aurèle LaRocque; 21. Jean Cate; 22. Dr. Alan Solem; 23. Carol Stein; 24. Arthur Merrill; 25. Mrs. Eugene Keferl; 26. John McCallum; 27. Mrs. Marc Imlay; 28. Dr. Henry Wehringer; 29. Albert Taxson; 30. W. L. Pratt, Jr. 31. John Root; 32. Myra Taylor; 33. Dr. J. P. E. Morrison; 34. David Bickel; 35. Dr. Dee Dundee; 36. Marion Hubbard; 37. Mrs. David Bickel; 38. Mrs. Henry van der Schalie; 39. Dr. Dorothea Franzen; 40. Dr. William Emerson; 41. Dr. Charlotte Dawley; 42. Dr. Patricia Morse; 43. Crawford Cate; 44. Gladys McCallum; 45. Mrs. David Stansbery; 46. Eugene Keferl; 47. Dr. David Stansbery; 48. Dr. Marc Imlay; 49. Dr. Juan Parodiz; 50. Unidentified; 51. Dr. Harold Murray; 52. Fred Berg; 53. Ruby Berg; 54. Ralph Sinclair; 55. Landon Ross; 56. Sinclair child; 57. Howard Root; 58. Dr. Harold Dundee; 59. Dr. Albert Mead; 60. Douglas McCallum; 61. Dr. Henry van der Schalie; 62. Richard Reeder; 63. Dr. Aurèle LaRocque; 64. Dr. Carl Gugler; 65. Mrs. Hugh Porter; 66. Dr. Arthur Clarke; 67. Jeanne Whiteside; 68. Mrs. Charles Jenner; 69. Mrs. Arthur Clarke; 70. Dr. William Starrett; 71. Dr. Charles D. Miles; 72. John D. Davis; 73. Wesley Porter; 74. Hugh Porter; 75. Dr. Lake Fowler; 76. Unidentified; 77. Mrs. Lake Fowler; 78. Dr. Charles Jenner; 79. Dr. Max Matteson; 80. Milton Werner; 81. David G. S. Wright; 82. Alice Burke; 83. Dr. Edward Roy, Jr.; 84. Kathryn Pfaff; 85. Julia Clench; 86. Lou Mason; 87. Tom Burke; 88. Fred Pfaff; 89. Harold Mills; 90. Vivian Mills; 91. Mrs. Adlai B. Wheel; 92. Capt. Adlai B. Wheel; 93. Mrs. Juan Parodiz.

John, Gladys and Douglas McCallum, Pittsburgh Shell Club, Wexford, Pennsylvania
Mr. and Mrs. Harvey Meyer, Sanibel–Captiva Shell Club, Captiva, Florida
Dr. Albert R. Mead, University of Arizona, Tucson, Arizona
Mr. and Mrs. Arthur Merrill, Bureau of Commercial Fisheries Laboratory, Oxford, Maryland
Dr. Charles D. Miles, University of Missouri, Kansas City, Missouri
Mr. and Mrs. Harold J. Mills, Chicago Shell Club, Chicago, Illinois
Dr. and Mrs. Joseph P. E. Morrison, U.S. National Museum, Washington, D.C.
Dr. M. Patricia Morse, Northeastern University, Nahant, Massachusetts
Dr. Harold D. Murray, Trinity University, San Antonio, Texas
Hellen Notter, Jacksonville Shell Club, Jacksonville, Florida
Dr. and Mrs. Juan J. Parodiz, Carnegie Museum, Pittsburgh, Pennsylvania
Mr. and Mrs. Otto V. Petr, Chicago Shell Club, Cicero, Chicago
Mr. and Mrs. F. R. Pfaff, Chicago Shell Club, Chicago, Illinois
Mr. and Mrs. Hugh Porter, Institute of Marine Sciences, Morehead City, North Carolina
W. L. Pratt, Jr., Fort Worth Museum of Science and Industry, Fort Worth, Texas
Dorothy Raeihle, New York Shell Club, Elmhurst, New York
Richard L. Reeder, University of Missouri, Kansas City, Missouri
John and Howard Root, Palm Beach County Shell Club, West Palm Beach, Florida
Dr. and Mrs. Joseph Rosewater, U.S. National Museum, Washington, D.C.
Landon T. Ross, Florida State University, Tallahassee, Florida
Dr. Edward C. Roy, Jr., Trinity University, San Antonio, Texas
Dr. and Mrs. van der Schalie, University Museums, University of Michigan
Mrs. Peter K. Schmidt, Wausau, Wisconsin
Mr. and Mrs. Ralph M. Sinclair, U.S. Department of Interior, FWPCA, Cincinnati, Ohio
Dr. and Mrs. Alan Solem, Field Museum of Natural History, Chicago
Dr. and Mrs. David Stansbery, Ohio State Museum, Columbus, Ohio
Dr. and Mrs. W. C. Starrett, Illinois Natural History Survey, Havana, Illinois
Carol B. Stein, Ohio State Museum, Columbus, Ohio
Mr. and Mrs. Albert Taxson, New York Shell Club, Bronx, New York
Myra Taylor, San Antonio Shell Club, San Antonio, Texas
Margaret Teskey, Marinette, Wisconsin
Dr. Ruth D. Turner, Museum of Comparative Zoology, Cambridge, Massachusetts
Henry G. Wehringer, M.D., Chicago Shell Club, Chicago, Illinois
Milton Werner, New York Shell Club, Brooklyn, New York
Mr. and Mrs. Adlai B. Wheel, Sr., Syracuse Boys Club, Syracuse, New York
Jeanne Whiteside, North Carolina Shell Club, Durham, North Carolina
David G. S. Wright, University of Guelph, Guelph, Ontario, Canada

THE AMERICAN MALACOLOGICAL UNION EXECUTIVE COUNCIL 1969–1970

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Fritz Haas
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HONORARY LIFE PRESIDENT

S. Stillman Berry

NEWS, NOTICES, NOTES

Low tides of July 16–20, 1970 (Thursday through Monday) will see the Thirty-sixth Annual Meeting of the American Malacological Union, Inc. assembled in Key West, Florida. Besides numerous contributed papers, special symposia on "The Biological Systematics of Marine Gastropods and Bivalves" organized by Dr. Robert Robertson of the Academy of Natural Sciences, Philadelphia, and "Commercial Marine Mollusks" organized by Dr. Arthur Merrill of the Bureau of Commercial Fisheries will be presented. Announcement of some additional special sessions will be made early next year. Of special interest to the amateur collectors will be talks on identification features in *Harpa* and cassids by leading authorities and the world's first "cone clinic," an identification session and demonstration of species differences in *Conus* chaired by William Old of the American Museum of Natural History. Several field trips for both land and marine oriented collectors are planned for the weekend break.

* * *

Our thanks to the 150 members who responded to the questionnaire sent out in March. Many included lengthy suggestions and offers of help which will be acknowledged personally. Some of the results from this survey are summarized below.

Meetings had been attended by 68%, with 14% having attended more than ten, but 61.3% only one to four meetings. Reasons for going to meetings, by both attenders and nonattenders, were primarily for contacts with scientists (83.9%). Meeting other collectors (64.2%) and the chance to collect in a new area (51.8%) were cited less frequently. The most popular suggestion for meetings was a session of reviews by specialists in certain fields (73.7%), with special symposia for collectors, a session of rental films, identification clinic for one or two families, and shell displays favored by 53–58%. Of those answering the questions, 60.7% favored one concurrent session of scientific papers in one room with a symposium for amateurs in another, and 62.2% favored more scientific papers with only 21.6% wanting fewer scientific papers (the remaining 16.2% thought the mix of papers was fine as at present). Timing of the meeting in Summer (77.3%) was clearly favored over Spring Vacation (20.5%) and 88.5% of those answering the question preferred not to associate with large organizations. Small college campuses (43.4%) and resort areas (32.6%) were much more popular than small city hotels (17.1%) or big city hotels (6.9%).

Features of the Annual Report were approved by large margins, with 87.6% liking the list of members, 82.5% the abstracts of scientific reports, 73.0% the informal reports on meetings, and 60.0% the reports on shell clubs. Sentiment was evenly divided between those wanting longer or shorter abstracts, and many people suggested that at least one or two full-length articles should be published.

The possibility of a newsletter was favored by 50.4%, opposed by 19.7% and presumably aroused no strong feelings among the 29.9% who did not answer the question. Of those answering (60%), a quarterly newsletter was

favored by 65.9% and semi-annually by 34.1%. Popular features for such a newsletter were requests from scientists for specimens (93.9%), reviews of new books for amateurs (92.7%), news of collecting trips by scientists and amateurs (89.0%), news of research projects (86.6%), and lists of forthcoming shell shows (78.0%). Less than half (48.9%) answered the section on whether the AMU should compile reference lists, and book lists (24.1%), willing identifiers (26.3%) and rental films (21.9%) were most popular. Nearly all would pay more for increased services.

On the basis of this poll and discussions at the recent Council Meeting, the initial number of an AMU newletter will be mailed out early next year. Members are invited to submit items of interest to Publications Editor M. K. Jacobson for this and for subsequent numbers. We plan to include one or two full-length articles in the 1970 Annual Report and to aim towards a quarterly newsletter within two years.

Alan Solem, President
American Malacological Union, Inc.

* * *

Because of too close planning barely enough copies of the 1968 Annual Bulletin to supply members were printed and the issue is out of print. $2.00 will be paid for all clean copies sent to the AMU Secretary.

* * *

Recent times have seen the death of two prominent zoologists who have published important works in the field of malacology. Dr. Robert Ervin Coker died on October 2, 1967 at the age of 92. In the course of his long life—he "retired" no fewer than three times—he served as director of several important institutions, some of which he was the first to organize. He made important contributions in oceanography and between 1905 and 1934 published important works on the fresh water naiads. More details of the life of this remarkable man can be found in the North Carolina Shell Club Bulletin, #5, 1968.

Dr. Libbie Hyman died on August 3, 1969 at the age of 80. She was a leading authority on invertebrates. Her study in six volumes called "The Invertebrates" is an outstanding reference work on the subject. Volume 6 of a projected 10 volume series deals with mollusks. The series will be completed by other workers. In addition to the treatise, Dr. Hyman wrote 145 scientific papers from 1914 to 1966. Since 1937 she was research associate at the American Museum of Natural History in New York. The New York Times, August 5, 1969 published an obituary with much detailed information on this outstanding scientist.

ANNUAL REPORTS OF AMU MEMBER SHELL CLUBS

BROWARD SHELL CLUB, Mary Lou Ingalls, President: Meetings are the second Wednesday of each month in the Community Room of the Atlantic Federal Savings and Loan, 1750 East Sunrise Blvd., Fort Lauderdale at 7:30 P.M.

Meeting highlights of the past year included the Christmas meeting in the home of Peg Burggraf, slides of living mollusks in aquaria by Neil Leeman, loan of the Glenn Burghardts' Chiton slides from California, and a July panel discussion on exchanging shells. Shellecture "Small Boat Dredging" opened a new field of shelling to several members. October saw a shelling trip to Marco Island.

The 1970 Shell Show dates are in mid-February and applications can be had from Mrs. Helen Jones, 1439 Grand Drive, Fort Lauderdale 33312.

Officers are: Mrs. Mary Lou Ingalls, President; Don Franks, Vice-President; Marilyn Duffy, Recording Secretary; Mrs. Helen Jones, Corresponding Secretary; Mrs. Mary Lou Stoner, Treasurer.

CHICAGO SHELL CLUB, Toni Wood, Corresponding Secretary: Meetings are the second Sunday of each month, September through June, at 2:00 PM at the Field Museum of Natural History, Chicago. Our fifth year of operation saw new records in attendance and enthusiasm. Meeting highlights included several Shellectures, talks by Alice and Tom Burke, Al and Charlotte Lindar on their collecting experiences, several motion pictures and a lecture on "A Ten Year Snail Trail" by Alan Solem, Curator of Lower Invertebrates at Field Museum. Two auctions and the St. Nick and Neptune Party were enjoyed by all.

Officers are: Albert J. Lindar, President: Thomas Burke, Vice-President; Walter Mitchell, Corresponding Secretary; Harriet Sankey, Recording Secretary; Alice Burke, Secretary; Helen Yast, Librarian.

CONCHOLOGICAL SECTION, BUFFALO MUSEUM OF SCIENCE, Ellen Holdway, Secretary: We continue to function in spite of many drawbacks, mainly because of our members moving away. We recently so lost Mrs. Paul Peters and Mr. and Mrs. Lester Greene. Mr. Dobmeier resigned as did Mr. and Mrs. Holmes and death took Mr. Stanley Adamski. We are, however, attracting pre-teenagers; two girls and two boys have recently joined us, all very knowledgable and good collectors, and so we have hope for the future.

Our September (1968) program featured the Greens who told of their visit to South Bimini where they collected nerites and chiton on the reef side, olives on the beach side and dredged in the open sea. In October our annual banquet was attended by thirty members and friends who later enjoyed an instructive program by Dr. John F. Storr, Biology Professor at New York State University at Buffalo—his topic, "How Flora and Fauna of the Deep Camouflage Themselves." In November we dredged—sorting over purchased dredgings, this time very fine, we got some real tiny treasurers.

No meeting in December, and in January we held annual elections. Mrs. Annette Vallone became our President, Mrs. Ethel Bishop Vice-President, Ellen Holdway to hold the combined offices of Secretary-Treasurer, the last relinquished by Miss Louise Becker who had served the club for fifteen years. Retiring President Mrs. Joseph Wandyez became Librarian, also presented the evening's entertainment with "Film Strip on the Seas."

In February Mr. Eugene Musial presented a program on the shells of Erie County, N.Y., both land and aquatic, showing a film taken two years ago by the late Morley Bishop and himself. For the March meeting all members were asked to bring their favorite shells; among them were land and freshwater clams and snails, cones, coweries, starfish, abalone, spider conchs plus a shell exhibition recently shown by a club member at the Williamsville Library. April brought a talk on the Paper Nautilus by the Greens prior to their departure and in May we enjoyed a Cate Shellecture, "Below the Tide."

CONNECTICUT VALLEY SHELL CLUB, Ruth H. Warren, Recording Secretary: We meet on the second Monday of each month at the Springfield Science Museum, Springfield, Massachusetts, or at the home of a member. Our 1969–70 officers are: Mary Robetts, President; Earl Reed, Vice-President; Charles Bingham, Treasurer; Elie Ley, Recording, Secretary; Priscilla Bingham, Corresponding Secretary. Our membership totals 45, including eight honorary.

We had many interesting meetings, more than usual by our own members. They included: an illustrated lecture on a Philippine Island trip; a trip to Mexico; one to Margarita Island; a talk on Fasciolaridae; displaying and telling about a prize shell or shelling experience; and a shell sale. We had one picnic meeting at the lake home of a member; our Christmas party with exchange of shell grab bag gifts; once the local Bird Club joined with us to hear R. Tucker Abbott talk on Relation between Birds and Mollusks. One meeting was cancelled due to a severe storm, and our field trip to Cape Cod was cancelled since too few of our members were able to go.

Some 3 by 5 inch cards were printed announcing our meeting nights, to be given out at the Springfield Museum, hoping to interest prospective new members.

The work project this year was the making of a portable case for displaying shells in schools, containing shells of various species and donated by our members. Fellow member Mrs. Henry Dow displayed shells at several Florida shows and won several ribbons, for which our club is duly proud.

THE GALVESTON SHELL CLUB, JaNeva I. Porter, Secretary: The Galveston Shell Club meets the third Tuesday of every month at 7:30 P.M. at the William Temple Foundation. Dues are $3.00 annually for active membership and $1.50 for corresponding membership.

Officers for the year 1969–70 are: Mrs. Laura Herman, President, Mrs. Laura Barnes, Vice-President and Mr. Hugo Bauer, Secretary-Treasurer. Dr. Harold Harry continues as advisor to the club. A newsletter is published monthly with news of the club's activities as well as scientific information about mollusks of the Texas Gulf coast.

August was the month selected for our first attempt at having a Shell Show and according to comments from visitors and members, it was a success. The excellent response of the public and the participation by members has encouraged us to make this an annual affair.

Regular meetings, after a short business session, are designed to increase our enjoyment and knowledge of the sea, marine life (mollusks in particular), and the natural history of associated flora and fauna in our local area. This is accomplished through films, lectures and exhibits by members and guest speakers. Programs are varied in order to offer something for all members, be they amateur, novice, advanced collectors or just beachcombers.

Membership increased and we now boast a membership of thirty-four adult members and six junior members.

GREATER ST. LOUIS SHELL CLUB, Bunny Gianino, Corresponding Secretary: Club meetings are held at 7:30 P.M. every second Wednesday of the month, in July and August, at the members' homes. The Museum of Science and Natural History, Oak Knoll Park, Clayton, Missouri (726-2888) will be happy to put you in contact with one of our officers for further information and directions.

Our Junior Division continues to flourish and their meetings are held on the first Sunday afternoon of the month, September thru June, at the Museum. Plans call for a Shell Show of their own and field trips as soon as possible.

Our club's project of supplying and working with the Audio-Visual Department of our City Board of Education has been very successful and with continued donations of shells from club members, should grow in requests for study shells in the future. This has been a most rewarding undertaking for the club members.

New books and color slides have been added to the club's library and are available to members for information, study, and use as subjects to be discussed or presented at our meetings.

Officers are: President, Mr. Al DuRocher; Vice-President-Treasurer, Mr. Mike Chiarottino; Recording Secretary, Mrs. Betty Salzman; Historian, Mrs. Tex Haid; Librarian, Mr. Charles Hertweck; Corresponding Secretary, Mrs. Bunny Gianino.

HAWAIIAN MALACOLOGICAL SOCIETY, Aline O'Brien, President: Meetings are the first Wednesday of each month at 7:30 P.M. in the Waikiki Aquarium, 2777 Kalakaua Ave., Honolulu. Our "Aloha!" is always out to visitors.

Each month the "Hawaiian Shell News" is published and mailed to all members. In June a successful shell auction to raise money towards publication costs was held, with especially brisk bidding on specimens "on the hoof" (directly from members' freezers). Each October a shell show is held, with the 1968 show at tha Ala Moana Shopping Center. The Smithsonian Award was shared by Olive Schoenberg and Betsy Harrison for their exhibit on "Some Parasitic Shells and Their Hosts." The "Annual Meeting" is the Christmas banquet, at which time the new officers are installed. Each member brings

a gift wrapped shell, is given a number, and then gets to "grab" a gift when his number is called.

Officers for 1968: Aline O'Brien, President; Beth Martin, Vice-President; Mique Pinkerton, Corresponding Secretary; Olive Schoenberg, Recording Secretary; George Campbell, Treasurer.

MIAMI MALACOLOGICAL SOCIETY, Fred Harper, President: We meet twice monthly year round for study, identification, exchange of knowledge and we concentrate on Florida-Caribbean marine shells. Several reef and shallow water trips, held each month for sociability and observation, are well attended. Shells are cleaned, identified and brought to meetings to show, share or trade. Our nine page QUARTERLY is available to other shell clubs at a cost of $1.50 a year. Corresponding Secretary, Mrs. Ellen Crovo, 2915 S.W. 102nd Avenue, Miami, Florida 33165 or Lt. Col. Corinne Edwards, Box 691, Miami, Florida 33133 our Treasurer will gladly receive your donation. Members willingly make local area trips collecting for scientific study and research. Requests from scientists for available mollusks (preserved in alcohol) with good data, are welcomed. Some members give Sea Life and Shell programs for school children on a regular basis. Most have salt water aquariums for observation. Most maintain properly catalogued shell collections and trade around the world. MMS is also interested in Florida fossil shells and the conservation of Florida Tree Snails. They have *Liguus fasciatus* living on trees in their yards, laying eggs in fall and hatching early in May. Men of MMS SCUBA together, returning with occasional rare shells, old collector-type bottles, fish or shellfish in season for meals, tired, sunburned but happy after a day away from TV and traffic. Librarian/Historian Mrs. Louise Futch, V. P. John Beers, Assistant Field Trip Chairman Sid Sneidar, Recording Secretary Ginny Webb, Marie Harper, Social Secretary.

NORTH CAROLINA SHELL CLUB, Ruth S. Dixon, Secretary: Quarterly meetings are held at different localities in the Carolinas. Our Spring Meeting on March 22–24 was at the Chesterfield Inn in Myrtle Beach and featured a workshop by Dr. John Ferguson on Fissurellidae, Acmaeidae and Lepetellidae illustrated by slides and exhibits; slides of Nancy and Wade Brown's trip to the Inca region of Peru; and movies on "Mollusks and Mysteries of the Deep" by James Wadsworth. Despite the cold, some collecting was possible. Summer Meeting in Atlantic Beach at the John Yancey Motor Hotel on May 17–19 featured a talk on the early history of Shackleford Banks by Capt. Josiah Bailey and a collecting trip on the "Diamond City" motor and sail boat with Capt. Bailey the following day. Saturday evening, Dr. A. F. Chestnut of the North Carolina Institute of Marine Sciences, spoke on the molluscan research of Dr. Robert Coker. Fall Meeting (October 11–13) at Topsail Beach, North Carolina featured talks by Jeanne Whiteside on Puerto Rico and Margaret Thomas as spokesman for "Six Babes" who shelled in Bimini. Winter Meeting (December 7) at North Caroline State Museum of Natural History in Raleigh included a workshop of Patellacea by Dr. John Ferguson and a talk by William Old of the American Museum on "Around the World with Mollusks."

Officers are: Hugh J. Porter, President; Walter Lowry, Vice-President; Ruth S. Dixon, Secretary; Elizabeth T. Mathews, Treasurer; Mrs. Charlotte Johnson, Historian, and Members-at-Large William Hammnet and John H. Ferguson.

PALM BEACH COUNTY SHELL CLUB, John Root, Vice-President: Our club held its tenth annual shell show, this year extended to two weeks that visits of classes of school children might be scheduled. Numerous interesting field trips included visits to Marathon, Peanut Island, Boca Grande and Port Salerno. Programs of Shellectures alternated with live speakers, auctions and parties.

Twelve issues of SEAFARI were published. We have contributed $500 to the building fund of the Science Museum and Planetarium of West Palm Beach, where we hold our meetings. A club-wide shell exchange with an Australian shell club was undertaken. And through the effort of club member Margaret Kennedy and Representative Bill James of Delray Beach the horse conch, *Pleuroploca gigantea* was made the state shell of Florida.

We meet the first Friday of each month, and officers are: William Ross, President; John Root, Vice-President; Lily Roberts, Secretary; W. W. Mills, Treasurer; Margaret Kennedy, Corresponding Secretary; Cynthia Plockelman, Seafari Editor.

PITTSBURGH SHELL CLUB, Mrs. June Snyder, Corresponding Secretary: Meetings are held the first Saturday of the month, November through June, at 2:00 P.M. at Mellon Bank, Fifth Avenue & Craig Street, Pittsburgh, Pa. Our first meeting of the season, in October, is held in the home of one of the members. This year's meeting was held in the home of Mrs. Bonnie Oatis. Norman Franke demonstrated scuba and skin diving methods and equipment, and a Chinese auction was also held.

Our programs are varied, and special features are the annual shell show, shell sale and field trips. Dr. David Stansbery was our guide for the fall field trip to the Grand River, at Rock Creek, Ohio, which was very profitable.

Our regular programs included "Malacology in South India," Dr. Ralph Dexter; "Ocean Operations—Over 500 Dives by Westinghouse DEEPSTAR 4000," William Sparks; "Some Rare & Interesting Shells From the Gulf of Mexico," Karen Vander Ven, Bonnie Oatis and June Snyder; "Shelling in the West Indies," Louis Dietrich; and "Batangas Bonanza," Jean Cate's Shellectures. We were honored to have Dr. Kenneth Boss, as the guest speaker for the fourth anniversary meeting. He spoke on "The Curious Clam," and following the meeting an anniversary dinner was held at a local restaurant for our guest and members.

Current Officers: President, Mrs. Gladys McCallum; Vice-President, Mr. Norman Franke; Recording Secretary, Miss Sharon Snyder; Corresponding Secretary, Mrs. June Snyder; Treasurer, Mrs. Esther Parodiz; Librarians, Mrs. Ruth Franke, Mrs. Jennie Lencher, and Miss Sharon Snyder; Historian, Mrs. Karen Vander Ven; Conchological Reporter, Mrs. Ruth Franke; Counselor, Dr. Juan J. Parodiz.

ROCHESTER SHELL AND SHORE CLUB: Mrs. Doris Barton, Corresponding Secretary: Meetings on fourth Wednesday September through June, 8:00 P.M., at the Charlotte Public Library Branch on Lake Ave. Visitors welcomed!

Our June auction and sale table netted a tidy sum for club projects. Shell exhibits displayed during the year: Monroe County Fair, August 12–17th; personal exhibit by Bee Plummer; a one-month club exhibit at Northgate Shopping Plaza; and a two-week display at General Railway Signal Works.

The Junior Shell Club is two years old: advisors, Bee Plummer and Joyce Myers. Our club newsletter, Rochester Shell Notes and Quotes, has completed a second year: Doris Barton, editor and publisher. Honors to Dr. Gene Wightman for ribbons won at Florida Shell Shows this spring and to Bert Porreca for his Sailor's Valentine which won him a blue ribbon at the Sanibel Shell Show. Our library now contains 61 books and pamphlets, and our membership includes 44 residents and 12 non-residents.

The highlight of the year was our annual Christmas Banquet when Dr. R. Tucker Abbott held us spellbound with his illustrated lecture on personal shell collecting experiences.

Other programs: September; Jean Cate's Shellecture "Shelling Around Australia's Coastline." October: Mrs. Marion Dake showed slides and movies of her shelling trip to the Bahamas. January, 1969: speaker Mr. John Honan discussed "Fossil Shells and Fish." Another Jean Cate Shellecture, "This Is Sanibel," for February, followed by sorting of Sanibel shell drift containing a Junonia as a prize—donated by Bert Porreca. March: Dr. Gaylord Rough, Professor of Biology at Alfred University spoke on "Ecology of Pond Life and Fresh Water Mollusks." And in April, Dr. John F. Storr, University of Buffalo, showed his film "Underwater Shell Safari In The Bahamas." Following the election in May, Bert Porreca regaled us with his special variety of slides taken on Sanibel.

1969–70 officers are: President, Mr. James Barton, 20 Newfield Dr., Rochester, N. Y. 14616: 1st Vice-President, Mr. Melvin Meyer: 2nd Vice-President, Mrs. Doris Barton: Secretary, Mrs. Gertrude Sandvik: and Treasurer, Mr. Frank Velte.

SAINT PETERSBURG SHELL CLUB, Mina Slinn, Corresponding Secretary: Our 1968–1969 meetings were held in the Science Center Room of the Presbyterian College in St. Petersburg. Twelve meetings were held, beginning October 11, 1968 and ending with April 11, 1969. Our programs were quite varied and included such topics as "Sharks and Shells in the Marquesas," "Shelling on Okinawa" and "Winter Trip to Isla Mujeres," all being well illustrated with color movies and slides. An evening's group discussion with members sharing experiences, "tricks of the trade" and general information aimed particularly toward our newer members was especially well received as was an unusually fine showing of color slides of live shells taken on a trip to the Florida Keys.

The year's activities included seven well-attended field trips to several different locations, a picnic for all held April 19th and an "End-O-Season" party given the Club by Mrs. Oma Cross, Curator at the St. Petersburgh Historical Society (Museum) on April 25th.

Activities the past year included field trips to neighboring communities to visit Natural History Museums, Shell Fairs and Gem and Mineral shows. Two members were able to attend the AMU Convention in Corpus Christi, Texas.

Our Educational Committee, Dorothy and Emma Hanssler, was kept busy assembling some fifty collections of Florida Shell which were sent to schools in various parts of the continental United States, Hawaii, Alaska and to Canada.

Our 22nd annual Shell Show was held from February 26 through March 2nd with an attendance of slightly under four thousand. The judges were Dr. R. Tucker Abbott, Dr. William H. Heard and William G. Lyons. Winner of the Smithsonian Institution Award was Bob Lipe with his exceptionally fine display of pictures taken of live shells in the Florida Keys shown along with the shells themselves entitled "Bring 'em back Alive." The Shell of the Show Award went to Flynn Ford for his very rare *Perotrochus gemma* from Andros Island.

Officers for the new year are: President, Florence Kuczynski; Vice-President, Robert Lipe; Treasurer, William R. Reader; Recording Secretary, Dorothy Hanssler; Corresponding Secretary, Mina M. Slinn; Librarian, Patricia Torrance; Directors at Large, J. Arch Mellor, Selma R. Lawson and Kitti Westfall.

SANIBEL-CAPTIVA SHELL CLUB, Harvey G. Meyer, President: Our meetings are held the third Monday of each month, November through April, alternating between the Captiva and Sanibel Community Houses. Meeting highlights included two Shellectures, "This is Sanibel" and "Small Boat Dredging" produced by Jean Cate; Dale Stingley's talk on "Shell Literature" illustrated with many books from his personal library; Dan Steger with slides and commentary on "Weird and Rare Shells of the Gulf of Mexico;" and William Lyons of the Florida Board of Conservation Marine Laboratory talking on the dredging work of "Operation Hourglass."

As in past years, we continue to donate important new shell books to the libraries on Sanibel and Captiva. Major emphasis is on our conservation programs. While our booklet supply is nearly exhausted, we are stepping up distribution of our conservation flyer through the Chamber of Commerce, motels and shops. The flood of visitors to Sanibel has caused severe over-collecting and three of our local mollusks are particularly endangered: *Melongena corona* (King's Crown), *Cyrtopleura costata* (Angel Wing), and *Pleuroploca gigantea* (Horse Conch). Visitors are complaining about the lack of fine specimen shells and our club is taking steps towards initiating legislation to protect our mollusks and to prevent over-collecting of live specimens.

Officers: Harvey G. Meyer, President; Mrs. J. C. McCaul, First Vice-President; Mrs. Edward Brunner, Second Vice-President; Mrs. Walter E. Strong, Corresponding Secretary; Mrs. Joe Dayton, Recording Secretary; Mrs. Mildred M. Onstine, Treasurer.

SOUTH FLORIDA SHELL CLUB, Fran Hutchings, Corresponding Secretary: Our current officers are: President, Mr. Guy Webb; Vice-President,

Mr. Harry Dietz; Recording Secretary, Mrs. Guy Webb; Corresponding Secretary, Mrs. Leonard Carlson; Treasurer, Miss Sylvia Bennis; Historian, Mrs. Clyde Standley; Editor, Miss Fran Hutchings.

Some of the programs provided by our members: Sylvia Bennis' slide presentation of her trip to Australia and New Zealand, accompanied by examples of native shellcraft and shells; Mr. Paul Shank presented a fascinating program on marine life, including such important biological events in the lives of marine specimens, as division of egg cells of a *Marginella*; Miss Fran Hutchings showed wonderful slide close-ups of live Florida tree snails, *Liguus fasciatus*; Mr. Neil Hepler gave valuable advice to members on the preparation and arrangement of their shell show exhibits; we went "Down Under" with Mrs. Ann Dudziak by means of slides and by the same medium Mr. Howard Lechner reviewed various Florida shell shows. Mr. William Bledsoe from Los Angeles showed us remarkable colored slides taken on a trip to the Galapagos Islands.

Field trips, our annual Christmas dinner, the old fashioned box lunch social, our booth at the Around the World Fair (annual money maker for the Museum of Science)—all were tremendously successful.

Our seventh shell show, theme "Mother Nature's Works of Art—Mollusks of Sea and Land from Far and Near" was a spectacular finale to our year; 350 feet of beautifully done exhibits were viewed by a gratifyingly large number of guests.

We welcome guests to our meetings held on the fourth Wednesday of each month in the Auditorium of the Museum of Science, 3280 South Miami Avenue, Miami, Florida.

IN MEMORIAM:

Mrs. Gene Coley

Gilbert Grau

George B. Wilmott

Mrs. William J. Clench

ACTIVE MEMBERS

Membership List Revised October 1, 1969

* Pacific Division member

Abbott, Dr. and Mrs. R. Tucker, Delaware Museum of Nat. Hist., Greenville, Del. 19807.

*Adams, Elmo W., 747 Winchester Dr., Burlingame, Calif. 94010 (Feeding habits of Gastropoda.)

Adams, Lawson, 2100 S. Bay St., Milwaukee, Wisc. 53207. (Amateur.)

Aguayo, Dr. Carlos G., College of Agriculture, Mayagüez, Puerto Rico 00709.

*Albano, Chas. M., P.O. Box 181, Kenmore, Wash. 98028 (shells-driftwood-research)

Albert, Mrs. Ernest, 905 Bayshore Blvd., Safety Harbor, Fla. 33572

Aldrich, Dr. Frederick A., Marine Sciences Research Lab., Memorial Univ., St. Johns, Newfoundland, Canada. (Decapod cephalopods.)

Alexander, Robt. C., 423 Warwick Rd., Wynnewood, Penn. 19096.

Allen, Dr. J. Frances, 6000 42nd Ave., #311, Hyattsville, Md. 20781

Allen, Mrs. Lawrence K., Box 822, Port Isabel, Texas 78578 (*Murex, Pecten*, world marines.)

Allen, Miss Letha S., 187 Argyle St., Yarmouth, Nova Scotia, Canada. (Mollusks in general.)

*Allison, Dr. Edwin C., Dept. Geology, San Diego State College, San Diego, Calif. 92115 (Fossil, Recent & mego-micro marine invertebrates.)

Anders, Kirk W., Shells of the Seas, Inc., P.O. Box 68, Kissimmee, Fla. 32741 (Volutidae; all rare shells.)

Anderson, Carleton J., Kettle Creek Rd., Weston, Conn. 06880

Arthur, John W., Nat. Water Quality Lab., 6201 Congdon Bldg., Duluth, Minn. 55804 (Water quality requirements of freshwater mollusks.)

Aslakson, Capt. and Mrs. Carl I., 5707 Wilson Lane, Bethesda, Md. 20034

Athearn, Herbert D., Rt. 5, Box 376, Cleveland, Tenn. 37311. (Freshwater mollusks.)

Athearn, Mrs. Roy C., 5105 N. Main St., Fall River, Mass. 02720. (Land shells.)

Auerbach, Stuart, 1710 Algonquin Trail, Maitland, Fla. 32751

*Avery, Mrs. Rada Gail, 1823 N. 40th St., Phoenix, Ariz. 85008. (Shells of N. America; exch.)

*Baily, Dr. Joshua L., P.O. Box 1891, La Jolla, Calif. 92038.

Baker, Dr. and Mrs. Horace B., 11 Chelten Rd., Havertown, Penn. 19083.

Baker, John A., P.O. Box 4524, Patrick AFB, Florida 32925 (General interest.)

*Baker, Nelson W., 279 Sherwood Dr., Santa Barbara, Calif. 93105. (General interest.)

Bark, Ann, 245 Winter St., Weston, Mass. 02193

Barlow, Alice Denison, 5 Downey Drive, Tenafly, N.J. 07670.

Bates, John M., Dept. Biology, Eastern Michigan College, Ypsilanti, Mich. 48197

Baum, Newman N., 83 Weaving Lane, Wantagh, L. I., N. Y. 11793

Bayne, C. J., Museum of Zool., Univ. of Mich., Ann Arbor, Mich. 48104 (Gastropod physiology.)

Beasley, Dr. Clark W., Dept. Biology, McMurry College, Abilene, Texas 79605 (Terrestrial and Freshwater mollusca.)

Becker, Albert F., 2157 Sunrise Dr., La Crosse, Wis. 54602. (Mississippi River shells.)

Becker, Miss Louise W., 2 Lexington Ave., Buffalo, N. Y. 14222.

Bedell, Adele Koto, 2643 Laundale Dr., Beloit, Wisc. 53511.

*Bedford, Charles A., Gen. Del., Roberts Creek, British Columbia, Canada.
Beetle, Mrs. Dorothy, Peninsular Junior Nature Museum, J. Clyde Morris Blvd., Newport News, Va. 23601 (Land and freshwater world shells).
Behrens, Grace, 222 Lenox Rd., Apt. 6-F, Brooklyn, N. Y. 11226. (Abalone; starfish.)
Bennett, Chas. G., 640 73rd St. Ocean, Marathon, Fla. 33050 (*Murex.*)
*Bequaert, Dr. Joseph C., Dept. of Entomology, Univ. of Ariz., Tucson, Ariz. 85717.
**Berg, Mr. and Mrs. Fred, 214 So. Canada, Santa Barbara, Calif. 93103
Berg, Mrs. Frederick C., Box 115, Georgetown, Md. 21930. (Shells of the Florida Keys.)
Berry, Dr. and Mrs. Elmer G., 1336 Bird Rd., Ann Arbor, Mich. 48103.
*Berry, Dr. S. Stillman, 1145 W. Highland Ave., Redlands, Calif. 92373.
Bickel, David, Dept. Geology, Ohio State Univ., 125 S. Oval Dr., Columbus, Ohio 43210. (Systematics and ecology of freshwater mollusca.)
Bijur, Jerome M., 135 7th Ave. N., Naples, Fla. 33940. (Buy, exch. Florida marine.)
Bingham, Frasier O., 1321 Nylic St., Tallahassee, Fla. 32304 (Gastropods; life histories.)
Bippus, Mr. and Mrs. Alvin C., 2743 Sagamore Rd., Toledo, Ohio 43606. (Marine gastropods.)
Bishop, Stephen H., 4039 Turnberry Circle, Houston, Texas 77025 (Metabolism.)
Blaine, Mr. and Mrs. Alger P., 237 19th Ave. S., St. Petersburg, Fla. 33705 (Summer: 74 Palmer Ave., Springfield, Mass. 01108)
Blinn, Dr. Walter C., Dept. Nat. Sci., Michigan State Univ., E. Lansing, Mich. 48823. (Ecology, behavior of land snails.)
*Bonus, Mrs. Warren, 26418 Marine View Dr., Kent, Wash. 98031 (All shells)
Boone, Mrs. Hollis Q., 3706 Rice Blvd., Houston, Texas 77005
Boss, Dr. Kenneth, Museum Comp. Zool., Cambridge, Mass. 02138
Bottimer, L. J., St. Francis Village, Crowley, Texas 76036 (Recent & fossil mollusks.)
Boyd, Dr. and Mrs. Eugene S., 295 Gillis Rd., Victor, N. Y. 14564. (Phylum Mollusca, all aspects.)
Bradfield, Mrs. Jesse, 6 Robin St., Rome, Ga. 30161 (General interest.)
Bradley, J. Chester, 604 Highland Rd., Ithaca, N.Y. 14850.
Bradley, John C., 469 Farmington Ave., Waterbury, Conn. 06710. (Travel and collect.)
Bradley, Mr. and Mrs. Wm., 11650 Nebraska Ave., Tampa, Fla. 33612 (All shells, esp. cones)
Branson, Branley A., P.O. Box 50, Eastern Ky. Univ., Richmond, Ky. 40475
*Bratcher, Twila L., 8121 Mulholland Terr., Hollywood, Calif. 90046.
Brooks, Mr. and Mrs. John C., 3050 Sunrise Blvd., Ft. Pierce, Fla. 33450
*Brown, Dorothy, 2535 Loring St., Pacific Beach, San Diego, Calif. 92109. (Pectens.)
Brown, Dr. and Mrs. Harvey E., 9455 S. W. 81st Ave., Miami, Fla. 33156.
Brown, Wade G., 1317 Arnette Ave., Durham, N. C. 27707
Brown, Mrs. Ward, 1420 N. Lakeside Dr., Lake Worth, Fla. 33460.
Broyles, Dr. and Mrs. Ralph E., 5701 Fairfield Dr., Ft. Wayne, Ind. 46807.
*Brunson, Dr. Royal Bruce, Montana State Univ., Missoula, Mont. 59801
*Bryan, Edwin H., Jr., Bishop Museum, Honolulu, Hawaii 96819. (Pacific biogeography and bibliography.)
Budnick, Roger A., 9722 Robinson Ave., Cleveland, Ohio 44125
Bullis, Harvey, Jr., Bureau Comm. Fisheries, Pascagoula, Miss. 39567.
Burch, Dr. John B., Museum of Zool., Univ. of Mich., Ann Arbor, Mich. 48104. (Land and freshwater mollusks.)

**Burch, Mr. and Mrs. John Q., 1300 Mayfield Rd., Apt. 61-L, Seal Beach, Calif. 90740

**Burch, Dr. and Mrs. Thos., 914 W. Palm Lane, Phoenix, Ariz. 85007. (Dredging.)

Bureau of Commercial Fisheries, Biological Laboratory, Oxford, Md. 21654

Burgers, Dr. and Mrs. J. M., 4622 Knox Rd., Apt. 7, College Park, Md. 20740.

**Burghardt, Mr. and Mrs. Glenn, 14453 Nassau Road, San Leandro, Calif. 94557

Burke, Alice L. and Thos. D., Jr., 1820 S. Austin Blvd., Cicero, Ill. 60650. (Marine mollusks of eastern U. S. A.)

Caffin, John, 528 W. New York Ave., DeLand, Fla. 32720 (World shells.)

Caldwell, Jas. L., III, 68 Nelson St., Georgetown, Mass. 01830 (Univalves)

*Campbell, Dr. G. Bruce, 11221 Elm St., Lynwood, Calif. 90268. (Typhiinae, Terebridae, E. Pacific.)

*Campbell, R. W., 5536 Hardwick St., Burnaby 2, British Columbia, Canada. (Pacific Coast marine and terrestrial gastropods; exch.)

Cann, Mrs. Ruth L., Massachusetts Ave., Boxboro RFD, Acton, Mass. 01720. (Marine shells; coll. and exch.)

Cardeza, Carlos, 2309 Sunset Blvd., Houston, Texas 77005 (Florida and Texas shells)

*Cardin, Glenn Wm., 7491 Valaria Dr., Highland, Cal. 92346

Carley, T. S., 407 Kingston, Deerfield, Ill. 60015

Carney, W. Patrick, Dept. Biology, Minot State College, Minot. N. D. 58701.

Carr, Mrs. Jack C., 912 Broadway, Normal, Ill. 61761. (*Cypraea*; *Murex*.)

Carr, Rose Elizabeth, 3001 Burdette St., New Orleans, La. 70125

Carriker, Dr. M. R., Marine Biological Lab., Woods Hole, Mass. 02543. (Shell demineralization; boring mechanisms of mollusks; marine ecology.)

Casa Ybel Hotel and Beach Club, Sanibel Is., Fla. 33957.

Castagna, Michael, Va. Inst. Marine Sci., Wachapreague, Va. 23480 (Pelecypod larval behavior.)

**Cate, Mr. and Mrs. Crawford N., 12719 San Vicente Blvd., Los Angeles, Calif. 90049. (*Mitra, Cypraea*; no exchanges.)

*Chace, Emery, 24205 Eshelman Ave., Lomita, Calif. 90717

Chandler, Carl and Doris, P.O. Box 621, Rt. 28, Chatham, Mass. 02633. (*Conus, Cypraea.*)

Chanley, Paul, Marine Laboratories, P.O. Box 861, Melbourne, Fla. 32901

Clark, Mrs. Dorla, Sun Circle Resort, Orange Beach, Ala. 36561.

Clark, Wm. F., Mark D. and Robert G., 504 Valley Rd., Terre Haute, Ind. 47803.

Clarke, Dr. and Mrs. Arthur H., Jr., Dept. of Mollusks, Nat'l Museum of Canada, Ottawa, Ontario, Canada

Clarke, Dr. Rosemary, 2049 University Ave., Dubuque, Iowa 52002.

Clayton, Mr. and Mrs. G. S., 4614 Marks, Corpus Christi, Texas 78411

Clench, Dr. Wm. J., Museum of Comp. Zool., Cambridge, Mass. 02138.

Cleveland Museum of Nat. Hist., 10600 E. Blvd., Cleveland, Ohio 44106.

Clover, Phillip W., Box 33, Div. 32, FPO, New York 09540 (*Marginella*, *Mitra*, *Voluta*, *Conus*, *Cypraea*.)

*Coan, Eugene, 891 San Jude Ave., Palo Alto, Calif. 94306.

Compitello, Mrs. Juliette, 399 St. John's Place, Brooklyn, N. Y. 11238.

Conde, Vincent, Redpath Museum, McGill Univ., Montreal, Quebec, Canada.

*Conway, Mrs. Richard, 1350 Oakland Rd., # 35, San Jose, Calif. 95112

Cooper, Robt. W. and Marjorie, 5012 Pfeiffer Rd., Peoria, Ill. 61607. (Florida marine shells; world *Murex, Pecten, Spondylus.*)

*Coplantz, Mrs. Karen, 1534 Olsen Dr., Gustine, Calif. 95322
Corbett, Wm. Phelps, 2939 Nelson St., Ft. Myers, Fla. 33901. (Exch. rare *Cypraea, Olivia, Murex.*)
Corey, Mrs. David S. K., 916 Airport Rd., Blacksburg, Va. 24060.
Corey, Nancy S. and Chas. L., 607 Elmwood Place, Austin, Texas 78705
Corgan, James X., Dept. Geography and Geology, Austin Peay State Univ., Clarksville, Tenn. 37040 (Microscopic gastropods).
*Correa, Mrs. Karleen, c/o Rio del Mar Foods, 64 Pine St., Suite 702, San Francisco, Calif. 94111 (Terebridae, Conidae.)
Cowles, Edw. F., Jr., 12 Hillcrest Ave., New Rochelle, N. Y. 10801. (Photography; tropical marine shells.)
Cox, Lee E., 7400 Grace St., Springfield, Va. 22150
Craine, Ruth A., Box 606, Oxford, N. Y. 13830
*Craig, Mrs. G. E. G., Apdo. Postal 448, Guaymas, Sonora, Mexico.
*Cramer, Frances L., 766 Obispo Ave., Long Beach, Calif. 90804. (Ecology; conservation.)
*Crittenden, Mrs. John S., 624 Waterfall Isle, Alameda, Calif. 94501.
Crum, Mrs. Dan, 3316 S.E. 3rd St., Apt. 2, Pompano Beach, Fla. 33062 (*Junonia*; Philippine and Cuban land and tree snails)
Cull, Mrs. Robt. R., 7927 Chippewa Rd., Brecksville, Ohio 44141.
Cummings, Raymond W., 37 Lynacres Blvd., Fayetteville, N. Y. 13066. (Shells of the West Indies, esp. Windward and Grenadine.)
Cutler, Henry H., 105 Abbott Rd., Wellesley Hills, Mass. 01570.
Cvancara, Dr. Alan Milton, Dept. Geology, U. of N. Dak., Grand Forks, N. Dak. (Recent freshwater mussels and Early Tertiary mollusks.)

D'Amico, Jos. S., 119 Persimmon Lane, Lake Jackson, Texas 77566.
*D'Attilio, Mr. and Mrs. A., 4124 47 St., San Diego, Cal. 92105
Danforth, Louise L., 729 Indian Beach Lane, Sarasota, Fla. 33580
Dater, Miss Caroll, Biol. Sci. Group, Univ. of Conn., Storrs, Conn. 06268
Davis, Derek S., Nova Scotia Museum, Halifax, Nova Scotia, Canada (Gastropod biology and taxonomy.)
Davis, Dr. Geo., Dept. Medical Zoology, 406 Med. Lab., U. S. Army Med. Comm., Japan. APO, San Francisco 96343.
Davis, Dr. John D., Clark Science Center, Smith College, Northampton, Mass. 01060 (Ecology of marine bivalves.)
Dawley, Dr. Charlotte, The Woman's College, Univ. of N. C., Greensboro, N. C. 27412.
Deatrick, Paul A., 218 S.W. 32 Ave., Miami, Fla. 33135 (*Strombus, Busycon.*)
DeLuca, Mrs. John A., Miss Gladys, Deborah Rd., Hanover, Mass. 02339.
*Demond, Joan, Dept. Geology, Univ. of Calif., Los Angeles, Calif. 90024.
Desmond, Hon. Thos., 94 Broadway, Newburgh, N. Y. 12550.
Dexter, Dr. and Mrs. Ralph W., Dept. Biol. Sci., Kent State Univ., Kent, Ohio 44240
Dietrich, Mr. and Mrs. Louis E., 310 Veri Ave., Pittsburgh, Penn. 15220.
Dixon, Mrs. Ruth S., 711 Parker St., Durham, N. C. 27701. (Marine mollusks.)
*Doucet, Mrs. P., Bay # 24, 3313 Dewdney Trunk Rd., Port Moody, B.C., Canada
Draeger, Mrs. Mary Alice, 726 S. 119 St., West Allis, Wisc. 53214
Duerr, Dr. Frederick, Rt. 1, Grand Forks, N. Dak. 58201
Dunbar, Edwin C., Dept. Zool., Southern State College, Springfield, S. Dak. 57062 (*Goniobasis* sp.)

Dundee, Dr. Dolores S., Dept. Biol., La. State Univ. in New Orleans, New Orleans, La. 70150. (Land mollusks; freshwater mussels.)

Dunn, V. Roger, 4727 27th Ave., So., Gulfport, Fla. 33711

Dvorak, Stanley J., 3856 W. 26th St., Chicago, Ill. 60623. (Muricidae.)

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ANNUAL REPORTS
for 1970

AMU, Thirty-Sixth Annual Meeting

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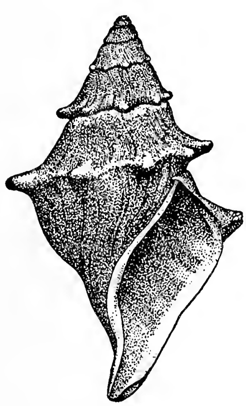

AMU, Thirty-Sixth Annual Meeting

C O N T E N T S

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AMERICAN MALACOLOGICAL UNION
THIRTY-SIXTH ANNUAL MEETING

Key West, Florida July 16–20, 1970

The American Malacological Union now has held annual meetings in three of the four corners of the United States: Rockland, Maine in 1941, San Diego, California in 1956, and in 1970, Key West, Florida. Key West claims to be the southernmost point in the USA. It may now also boast of having entertained the greatest number of AMU members to be assembled in annual session, 268.

The meeting was a full five days long and allowed free time for getting acquainted with the newcomers. A mass sightseeing tour on the evening of the opening day afforded a comprehensive look at the historic old city. No record was kept of those who later were to miss a paper, or a half-day session, in order to tour the homes of James Audubon and Ernest Hemingway, to visit the nearby Civil War fort or to browse in the fascinating shops in the old section of town where the architecture reflects the West Indies origin of the builders.

In the auditorium of the Key Wester Motel, President Alan Solem presided over a record number of papers, 52. Some were grouped as symposia under the chairmanship of Dr. Arthur S. Merrill (Commercial Marine Mollusks of the United States), Dr. Albert R. Mead (Land and Freshwater Mollusks Introduced into North America), and Dr. Robert Robertson (Biological Systematics of Marine Bivalves and Gastropods).

One evening was devoted to a conservation forum, and on another Shell Club Night featured two outstanding slide programs and concluded with a silent auction of donated shells. The Executive Council met on Friday night and the annual business meeting (see page 87) occupied a part of Monday afternoon.

Saturday's field trips had been planned to take advantage of the July neap tide, lowest of the year. One hundred divers-snorklers-waders-'combers were transported nine miles to sea and landed on a tiny bit of sand occupied by an unmanned lighthouse surrounded by square miles of shallow coral reef. Another lot joined the motor caravan for a trip up the Keys, stopping at roadside collecting spots while yet a third small group was introduced to *Liguus* collecting by Dr. Bill Clench and Mr. Archie Jones, authorities on the lovely, vanishing tree snail. Mr. Jones has won national recognition for his voluntary work of transplanting colonies of established color forms from endangered sites to hammocks in Everglades National Park where they will be spared for a while from the ravages of civilization.

The annual dinner on Monday evening was, as always, the single semi-formal event of the meeting. Preceded by a social hour, the meal was buffet-style roast beef, barbecued ribs and a fish casserole, and at its conclusion the evening was high-lighted by an illustrated lecture by Dr. Edward T. LaRoe of the University of Miami; his topic, Living Cephalopods.

As his final act in office, Retiring President Alan Solem introduced the following Past Presidents in order of their dates of service: William J. Clench, 1935; Joseph P. E. Morrison, 1951; Morris Karl Jacobson, 1955; R. Tucker

Abbott, 1959; Thomas E. Pulley, 1961; Albert R. Mead, 1963; Juan José Parodiz, 1965; Arthur H. Clarke, Jr., 1968. He then surrendered the gavel to President-Elect David H. Stansbery who introduced Retiring Secretary Margaret C. Teskey, then declared the 1970 Annual AMU Meeting to be over.

Margaret Crockett Teskey

(Since with the above report my services as AMU Secretary come to an end, it is appropriate to express here my gratitude to the many dear people without whose aid and council I could not have continued in office. For nearly two decades my association with the American Malacological Union has resulted in great personal benefit. Friendships made and continued have enriched my life immeasurably, while knowledge gained from exposure to the academic work reported here could have been acquired in no other way. May the AMU continue to grow in size, scope and usefulness, may the years ahead be kind to us all. M.C.T.)

ABSTRACTS OF PAPERS PRESENTED AT THE THIRTY-SIXTH AMU MEETING

HISTORY OF FLORIDA MALACOLOGY

William J. Clench
Museum of Comparative Zoology, Harvard University
Cambridge, Massachusetts

Abstract

A survey covering the early collectors and students of Florida land, freshwater and marine mollusks.

THE INTRODUCED FRESHWATER SNAIL, *MARISA*

Catherine H. Robins
Institute of Marine Sciences, Miami, Florida

Abstract

The South American freshwater snail *Marisa cornuarietis* (Ampullariidae) is one of many aquatic exotic animals introduced into South Florida's network of drainage canals. The snail's distribution, natural history, and tolerance of chemical and physical parameters encountered in Florida are described. Implications of its potential spread into the Everglades are considered.

FLORIDA UNDERSEA PARKS

Martin F. Gomon
Institute of Marine Sciences, Miami, Florida

The marine waters immediately adjacent South Florida are tropical in nature and contain the only living coral reefs in North America. In order to maintain the unique quality of these areas certain portions have been set aside by the state and national governments as parks. In South Florida four park areas contain submerged marine lands.

The Fort Jefferson National Monument, 68 miles southwest of Key West encompasses some 47,000 acres, fewer than 90 of which are above the mean high water line. The area is very shallow and contains seven small keys known collectively as the Dry Tortugas Islands. These include Garden Key with the imposing Fort Jefferson, and Loggerhead Key, the site of the former Tortugas Laboratory of the Carnegie Institution.

Although the Everglades National Park is commonly thought of as an inland park, more than one-fourth of the park extends beyond the south Florida coastline into the shallow waters of Florida Bay and the Gulf of Mexico. The waters contain large areas of grass and algae beds, occasional coral heads and stretches of soft coral cover, and littoral zones dominated by mangroves and saw grasses. This area is extremely important as a breeding and rearing ground

for shrimps of the genus *Penaeus* that comprise the largest fishery of the United States.

The John Pennekamp Coral Reef State Park, a totally submerged 21 by 4 mile tract of land off the southeastern coast of Key Largo, contains several beautiful reefs with some of the most magnificent stands of elkhorn and staghorn coral still available in Florida Keys.

The Biscayne National Monument lies immediately to the north of the Pennekamp State Park but it extends west to the coastal shoreline of Florida. The monument includes the extreme north end of Card Sound, South Biscayne Bay, 25 keys and islands most of which are a northern continuation of the Florida Keys, and the area seaward to the 10 fathom curve. The northern boundary encloses the north end of Sands Key and the southern end of Triumph Reef. The Biscayne National Monument encompasses most of the ecological communities common to the other three parks in South Florida and serves as a good area for a cross sectional study of marine conditions of the region.

Geologically, South Florida is formed from two Pleistocene limestone formations: The Key Largo Limestone and the Miami Limestone, deposited during the third interglacial period, some 75,000 to 100,000 years ago. The Key Largo Limestone probably represents a series of fossil patch reefs and forms the surface of the upper Keys from Soldier Key to the Newfound Harbor Keys. The Miami Limestone forms the east coast ridge of Florida from north of Ft. Lauderdale to Florida City. To the South and west it dips to provide the floor of the Everglades and Florida Bay, and rises again to form the lower Keys from Big Pine Key to Key West. Subsequent glacial periods markedly lowered the sea level and subjected the limestone to weathering and erosion, accounting for the configuration of South Florida today.

Ecologically and hydrographically the Biscayne National Monument may be divided into two basic areas: the south Biscayne Bay and Northern Card Sound region and the offshore region from the line of Keys seaward to the 10 fathom curve. South Biscayne Bay is a largely enclosed shallow estuary rarely exceeding 8 to 10 feet in depth. Because of the surrounding barriers, water circulation is largely confined to a tidal flushing through cuts between the Keys. The Bay area is, therefore, subjected constantly to external factors and experiences greater fluctuations in physical parameters than the offshore area.

Bottom communities in the Bay include soft bottom algae and marine grasses along the western edge, soft corals, sponges, and some of the hardier corals on the more exposed limestone bottom of the central bay, and more marine grass on the eastern side of the bay. The *Thalassia* (turtle grass) community contains probably the richest assemblage in species and number of individuals of any known marine community. The terrestrial borders of the Bay are mostly lined by mangroves. These areas form an extremely important community in stabilizing the shoreline, acting to filter the land runoff and contributing to the organic nutrients by leaf droppage and supporting other organisms.

The seaward side of the Keys is subjected to much greater weathering than the bayside and is thus rockier and rougher in configuration. The areas above

and below the water line may be divided into a number of zones depending on their exposure to seawater. These are the white, grey, black, and yellow zones. Each has a characteristic fauna. Beyond the intertidal zone a limestone lower platform pitted by storm-influenced wave action usually extends seaward. The reef flats extending from the keys to the outer reefs are covered largely by marine grass beds and contain patch reefs and areas of bare, white carbonate sand. The patch reefs are prominent structures formed of living masses of coral heads rising from the bottom in 10-20 feet of water.

The outer reef may be divided into three or four areas; the back reef, the top reef, the reef face, and in most cases the deep reef. The back reef is a relatively narrow area on the sheltered side of the reef characterized by a surface layer of broken coral rubble. The top reef is commonly an area of raised dead coral limestone formations covered to varying extents by stands of living hard and soft corals. This area is often deeply cut by sandy bottomed surge channels. The reef face is the rather abrupt seaward side of the reef. Between 80 and 100 feet the bottom usually levels again to form the deep reef.

The undersea park is formed not merely for the preservation of a unique area but for the maintenance of a natural phenomenon for both the scientist and interested public to observe, study, and enjoy, unchanging in natural beauty from generation to generation.

THE GLASS SCALLOP *PROPEAMUSSIUM*, A LIVING RELICT OF THE PAST

Thomas R. Waller
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Propeamussium is representative of a group of thin-shelled, translucent scallops found in most of the world's oceans and in waters ranging from 150 to 1500 fathoms in depth. In 1954 R. Tucker Abbott moved *Propeamussium* out of the family Pectinidae into a family of its own, the Propeamussiidae, on anatomical grounds, although these grounds were not specified. Subsequent classifications of the Bivalvia have not followed this split at the family level and have done little to clarify a long history of confusion involving *Amusium* and *Propeamussium*.

A reexamination of both the hard and soft parts of *Propeamussium* from the Caribbean and Gulf of Mexico is revealing many features not previously described. The shell microstructure alone provides a sound basis for a family-rank distinction and suggests that *Propeamussium* and its allies are living relicts of a group thought to have become extinct at the end of the Paleozoic Era, 225 million years ago.

The shells of Pectinidae, as exemplified by those of the type-species of the genera *Chlamys* and *Pecten*, consist primarily of foliated calcite in both valves. Prismatic calcite is found only in an early growth stage of the right valve, on which it forms an exterior layer extending less than 2 mm from the origin of growth in *Chlamys* and allied genera and from 3 to 5 mm in *Pecten* and allied genera. Cross-lamellar aragonite is limited to the area within the

pallial line of both valves, where it may be very thin or absent altogether. The type species of *Amusium, A. pleuronectes,* strongly resembles true *Pecten* in shell microstructure. The internal ribs of *Amusium* are the result of crenulations of the foliated calcite layer, as are the external costae and deep radial plicae of *Pecten, Chlamys,* and other Pectinidae.

In contrast, *Propeamussium* (e.g., *P. dalli*) has a foliated structure only in the exterior layer of its left valve, where this layer comprises only about half of the thickness of the valve. About half of the thickness of the right valve (0.16 mm, measured just within the pallial line of a specimen with dorsoventral diameter of 67 mm) is formed by an exterior layer of prismatic calcite that persists throughout growth over most of the disk. The other half (0.12 mm) of the thickness of both the right and left valves consists of crossed-lamellar aragonite covering the area inside of the pallial line and also extending well outside of the pallial line. On the right valve, foliated calcite is found only as an exceedingly thin layer (0.03 mm) between the inner crossed-lamellar aragonite and the exterior prismatic calcite.

Highly unusual features of the shell of *Propeamussium* are a lateral change in the prismatic layer of the right valve, and the nature of the internal ribs. The prismatic layer changes laterally to foliated structure on the disk flanks and auricles. A concomitant change occurs in the thin middle foliated layer, the outcrop of which departs from parallelism with the margins of the disk and the inner crossed-lamellar layer by expanding laterally and merging with the laterally altered external prismatic layer. The internal ribs and auricular crura are slats of foliated calcite imbedded within the crossed-lamellar layer. Secretion of these ribs must involve specialized areas of cells on the mantle distributed outside of the pallial line but within the border of outcrop between the crossed-lamellar and foliated layers. As these specialized "spots" migrate distally with growth, they transgress crossed-lamellar structure and are immediately followed by additional crossed-lamellar structure, leaving the foliated internal ribs as evidence of their migratory paths.

The predominant prismatic calcite—crossed-lamellar aragonite right valve and foliated calcite—crossed-lamellar aragonite left valve of *Propeamussium* and its allies resemble the plicatulids, spondylids, limids, and many Mesozoic pectinids, all of which have crossed-lamellar layers extending outside of the pallial line. But all of these other groups are dominated by the foliated structure and have prismatic structure limited to very early growth stages of the right valve or (in the plicatulids) absent altogether. The anomiids and oysters are also predominantly foliated calcite, although the oysters have a thin external prismatic layer persisting on the right valve throughout growth.

The only bivalves that resemble *Propeamussium* and allies in shell microstructure are the extinct Paleozoic Pernopectinidae. Like *Propeamussium, Pernopecten* has a right valve with prismatic structure forming the exterior throughout growth and with crossed-lamellar structure forming the interior; the left valve is foliated calcite on the exterior and crossed-lamellar aragonite on the interior. Lateral change in the exterior prismatic layer of the right valve, as in *Propeamussium,* has been detected in *Pernopecten* from the Mississippian Period. *Pernopecten* lacks internal ribs, but there is evidence that its auricular crura may be imbedded in a matrix of differing mineralogy as are the internal ribs of *Propeamussium.* The only difficulty in establishing

a direct evolutionary relationship between the Paleozoic and living groups is the absence of links in the Mesozoic Era, although these links may be provided by groups under study.

Dissection of propeamussiids reveals that there are numerous anatomical surprises, only some of which have been reported by previous investigators. There is a total lack of ocelli; there are no guard tentacles on the edges of the velum; and there is no trace of any pedal retractor insertion on the left valve. These, and other features as yet undescribed, are unknown in the common Pectinidae.

Shell microstructure and soft-part anatomy thus provide ample evidence for the separation of the Propeamussiidae and the Pectinidae. The Propeamussiidae, today largely restricted to waters of the continental slopes and abyssal regions, most closely resemble the Pernopectinidae of the Paleozoic, and available evidence strongly suggests that the living forms may actually be surviving relicts of the group thought to have been extinct for 225 million years. Further study of this ancient group should lead to important revisions of pectinid classification and to greater understanding of the processes of calcification and shell formation in mollusks.

NAMES FOR THE SUBFAMILY HYDROBIINAE

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One fundamental character of the subfamily Hydrobiinae was outlined in 1949, in the A.M.U. annual report for 1948, pages 13–15. A simple male organ with vas deferens only differentiates this subfamily from other groups of the Family Hydrobiidae, which possess two or three tubular and functional ducts in the verge.

The Pomatiopsinae Stimpson 1865 (1) (*Pomatiopsis*) are supposed to have a supra-pedal groove. The Triculinae Annandale 1924 (2) have such a groove, half-defined, when it is functioning in locomotion. The Hydrobiinae Troschel 1857 (3) are not supposed to show a supra-pedal groove, at least structurally. The Tomichiinae Wenz 1939 (4) are too close in characters to be different from the Hydrobiinae. The Delavayidae Annandale 1924 (5) are proven identical to Hydrobiinae by even the most superficial examination. The Benedictiinae Clessin 1880 (6) are too close to a giant *Cincinnatia* to be separated, even if they are from Lake Baikal. Generic differences are not subfamily differences. The Littoridininae Gray 1857 (7) cannot be considered a different subfamily on the difference between one or of more than one glandular area on the otherwise simple verge. Division on difference of degree (not of structures) is not normal biology. The Paludiscalinae Taylor 1966 (8) is too close to the monotypic genus *Tryonia* to be separated except as a genus or subgenus. The Lithoglyphinae Troschel 1857 (9) differ only in shell shape from the Hydrobiinae "Triculinae" and "Delavayidae." This is not a subfamily anatomical character. The Fluminicolinae Clessin 1880 (10) is identical since our present knowledge confirms Clessin's statement of 1880 that *Lithoglyphus* as a genus includes the West American *Fluminicola* of Stimpson. The *Cochliopinae* of Tryon 1866 (11) marks just another difference in shell shape, with no sub-

family (anatomical) difference. Since *Mexithauma* (the subfamily "Mexithaumatinae" of Taylor 1966) (12) is only a modified *Cochliopina* with an epidermal fringe, and a verge identical to that of *Cochliopina,* it cannot be in a different subfamily. In identical fashion the so-called Nymphophilinae Taylor 1966 (13) is based on a modified species of *Subcochliopa.* It may not even differ generically from the trochoid-shaped Panamic *Subcochliopa.* The Horatiini Taylor 1966 (14) do not differ since the only American group (*Coahuilix* Taylor) is the dwarf cave-inhabiting form of *Cochliopina* (from Texas and Mexico).

The Clenchiellini Taylor 1966 (15) is also another variation in degree of shell shape only, a planorboid hydrobiine shell.

The neritoid-shaped "Lepyridae" of Pilsbry and Olsson 1951 (16) concerns only a highly modified shell shape of a hydrobiine snail. The hydrobiine *Lacunopsis* of Southeast Asia (Mekong drainage) is even more neritoid, yet also is proven hydrobiine by its male anatomy.

In other words, there have beeen at least (16) synonymous subfamily names given to confluent parts of the one biological subfamily *Hydrobiinae,* first named by Troschel in 1857.

EVOLUTION OF A SHELLER—AMATEUR TO PUBLISHING PRO

Morris K. Jacobson
American Museum of Natural History, New York, New York

A former AMU president reviews his malacological history. Early capture, fanatic enthusiasm, friendly human contacts, selfless assistance and guidance from understanding professionals, and huge amounts of good luck all played a role.

SYMPOSIUM ON COMMERCIAL MARINE MOLLUSKS OF THE UNITED STATES

ARTHUR S. MERRILL, CONVENER

INTRODUCTION

The American Malacological Union has traditionally been concerned with the taxonomy, ecology, general biology, and conservation of the mollusks of the United States and elsewhere. This symposium was convened to explore the commercial aspects of our molluscan fauna, and to describe in detail the species and techniques involved in fisheries for this significant sector of our living aquatic resources. The symposium also defined those critical problems, particularly disease and pollution, that limit shellfish production.

In any review of this type, it soon becomes obvious that one of the weak points in the assessment of world fisheries is the lack of intensive fishery monitoring procedures. It is certainly not coincidental that generally the leading fishery nations are those that undertake monitor programs and that base fisheries management on these data. Assessment studies are particularly relevant in molluscan fisheries, since the animals are mostly sessile and more accurate population data can be acquired than for highly mobile finfish species.

Commercial mollusks are the most important group of invertebrates in world fisheries. In the 10-year period 1958–68, the world catch increased by 50% and this dramatic expansion of molluscan fisheries promises to continue. According to figures published by the Food and Agriculture Organization (FAO), production of mollusks in 1967, the latest year for which full statistics are available, amounted to 3.12 million metric tons by live weight (see Table I). Thus, the total weight of mollusks was more than double the nearest invertebrate competitor, the crustaceans.

Oysters are perennially the leaders in the molluscan fisheries, and a catch of 839 thousand metric tons was recorded for 1967. The United States accounts for almost half of the catch according to the FAO statistics in table I. However, since FAO bases its figures on live weight, or the weight of the animal *and* its shell, the figures do not give a true picture of the actual edible catch. Using other sources, we find that the Bureau of Commercial Fisheries Statistical Digest reports landings of 60 million pounds of oyster meats for 1967, while Fujiya (1970) gives the oyster production of Japan in 1967 as 45 thousand metric tons of shucked meats, or 99 million pounds. This difference in the live weight and shucked meat figures reflects a difference in fishery practices of the two countries. It appears that Japan, with its off-bottom methods of oyster culture, is harvesting a product which has a thinner shell than the wild or natural bar oyster of the United States. This discrepancy does not enter into the figuring of production of other shellfish, with the possible exception of the scallop.

Japan and the United States have competed not only for eminence in oyster production but generally for top rank in the molluscan fisheries. Japan is the dominant country for both squid (no. 2 in world shellfisheries tonnage) and for octopus (no. 5). The Japanese catch of squid, 83% of the

Table I. World Molluscan Shellfish Catch—1967
Arranged According to Production, with Dominant Country and Catch*
(in Metric Tons Live Weight**)

Species	Total Catch	Dominant Country	Catch	%
Oyster (Ostreidae)	839,000	United States	415,000	49
Squid (Loliginidae, Ommastrephidae)	697,000	Japan	581,100	83
Clam (Veneridae, Solenidae, Myacidae, Mactridae)	417,000	United States	184,500	44
Mussel (Mytilidae)	273,000	Netherlands	85,600	31
Octopus (*Octopus* spp., *Eledone* spp.)	181,000	Japan	98,200	54
Scallop (Pectinidae)	134,000	United States	54,900	41
Cockle (Cardiidae)	74,000	Malaysia	26,900	36
Cuttlefish (*Sepia* spp., *Sepiola* spp.)	60,000	Spain	16,900	28
Freshwater Clam (*Corbicula* spp., Unionidae)	55,000	Japan	42,000	76
Arkshell (Arcidae)	29,000	Malaysia	26,900	93
Abalone (Haliotidae)	20,000	Mexico	6,400	32
Conch, Whelk, Top-Shell, etc. (Strombidae, Buccinidae, *Busycon* spp., Trochidae, etc.)	19,000	Japan	7,200	38
Winkle (Littorinidae)	4,000	Ireland	2,000	50
TOTAL WORLD CATCH (including miscellaneous mollusks not mentioned above)	3,120,000			

* Source: FAO—1969 Yearbook of Fishery Statistics, Catches and Landings—1968, Vol. 26: 318 p.

** Live Weight = weight of shell and animal

world total, amounting to 581,100 metric tons, is the largest molluscan fishery reported in 1967 for a single country.

In 1967 the United States was the chief producer of clams by a slight margin, but statistics show that Japan has been a close competitor here also and has on occasion exceeded U. S. production. However, the U. S. clam industry is thought to have a great potential, especially in the opening up of ocean quahog and razor clam beds and exploitation of fisheries for *Rangia* and the sunray clam. The 1967 fishery was based almost totally on the hard, soft, and surf clams. The United States and Canada account for most of the scallops taken; this fishery is not only no. 6 in the world list, but also one of the more valuable. The growing fishery for the calico scallop of the southeastern Atlantic coast has contributed to increased landings and value.

The Netherlands excels in the production of mussels, but other European countries and Chile also have large mussel fisheries. Spain was the top country for cuttlefish, leading Japan by only a slight margin. Malaysia has the largest fishery for cockles and accounts for nearly all of the total catch of arkshells. The Mexican fishery for abalones slightly exceeds Japan's, but

Japan again is tops in the fishery for conchs and whelks. The fishery for winkles is largely confined to the British Isles, where Ireland produces 50% of the world catch.

A review of world fisheries, then, shows that Japan is far and away the dominant country in shellfisheries. Leading in the production of oyster meats, squid, octopus, and conchs; almost equaling the production of the dominant country in the case of clams, cuttlefish, and abalone; leading as well in the fishery for the freshwater clam—the superior position of Japan cannot be denied. The United States follows with second place in importance, but its major fisheries are both large and impressive. Even more impressive is the potential estimated for developing new fisheries and increased exploitation of molluscan resources that are now underutilized.

The following contributions summarize individual presentations at the 36th meeting of the AMU at Key West, Fla., on July 17, 1970. The participants are authorities in the various fields of commercial mollusk interests. The symposium as a whole describes the past history and the current status of our molluscan fisheries, and offers some forecasts on the part they may play in meeting future protein requirements. The convener has taken the liberty to write this introduction and the summary following the contributions.

A MONTAGE OF OYSTER CULTURE FROM PAST TO FUTURE[1]

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Oysters are the most prolific and tolerant of mollusk species and a vast array of predators and diseases did not prevent the formation of natural reefs or beds. Oyster communities, the first recognized ecosystems (Möbius), thrived until man intervened—beginning with the Romans in Britain and threatening to end with industrialized man's monstrous reef-devouring suction dredges in the Gulf of Mexico and the Chesapeake Bay. The famous natural public beds of France were depleted over a century ago and private culture was adopted. On the East Coast of North America low salinities resulting from spring flows of large rivers such as the Mississippi, Susquehanna, Potomac and Delaware, provide sanctuaries where breeding stocks survive in the near absence of predators, diseases and most competitors, and despite overfishing by man. These sanctuaries are now threatened by storage, diversion and pollution of water to satisfy rapidly increasing demands for water and power.

The oyster fisheries of the world are almost completely dependent upon natural sets of "wild" oysters. "Free" fisheries on public beds on the East Coast are enmeshed in a set of traditions and limitations, enshrined with the magic word conservation, that insures inefficiency of harvest and use. Antiquated gears (tongs and tooth dredges) persist in all areas except New England although hydraulic dredges are available and utilized in clam fisheries (*Mya*, *Mercenaria*, *Spisula*). Seed oysters are produced cheaply, on public beds mostly, but misuse in time and place of transplanting is prevalent.

[1] Contribution no. 373, Virginia Institute of Marine Science.

Oysters have become a luxury food in most regions of the world and producers depend upon scarcity and high prices rather than productivity for profits. Recent mid-Atlantic coast losses to a protozoan disease, caused by *Minchinia nelsoni* and called MSX, have accentuated the problem. Oystermen located in low-salinity areas free of MSX have made generous profits in the 1960's whereas their neighbors in high salinities were forced out of business. Setting failed in the James River that had supplied most seed oysters for private grounds in Chesapeake Bay for nearly a century. Production from James River dropped to one-fifth the level sustained in the 1950's and seed production declined from over 2,000,000 bushels annually to 264,000 in 1969–1970. Chesapeake Bay, Maryland with its low salinity areas has increased production in the last three years and Louisiana also provides big crops between hurricanes. Yet the price of landed fresh-shucked oysters has dropped to $3 to $4 a bushel, similar to that prevailing before the mid-Atlantic catastrophe. Retail prices remain high and consumption has contracted severely in ten years.

The most encouraging new developments have come out of New England and the Pacific coast. Certain generalizations may be made regarding oyster biology with change of climate from north to south along the East Coast. Spatfall or setting is usually deficient north of Chesapeake Bay and excessive south of it. Growth is slow in the north, requiring four to six years to market oysters, whereas 18 months is adequate in the Gulf of Mexico. Predators and diseases tend to increase in variety and severity from north to south.

Oysters grown in Long Island Sound and north are all sold for half-shell stock at prices of $16 to over $20 per bushel. This has permitted considerably more effort in rearing oysters and protecting them. Several hatcheries are producing spat with centrifuged natural water. Grounds are treated for predators by spreading quick lime on starfish and polystream-treated sand (heavy oils) and Sevin to kill drilling snails. Also seed beds are prepared by vacuum cleaner-like suction dredges. Beds are monitored for predators and other problems by SCUBA divers and starfish mop patrols.

A recent discovery by a private hatchery at Pigeon Point, California, of a method for producing cultchless or free spat has stimulated adoption of almost as many similar methods as there are hatcheries. Patents for ground oyster shell, rubber-covered automobile tire beads, and a variety of other cultches have been sought or obtained. Most of these efforts are aimed at increasing spatfall and quality by getting cultch off the bottom and producing single well-shaped oysters for machine shucking (not yet fully attained). West Coast producers, emulating the Japanese, have produced significant quantities of Pacific oyster seed on shell strings in favorable setting areas (Dabob Bay and Pendrell Sound are examples).

Control of oyster fisheries is necessary to permit mechanization, improve quality and increase production. The easiest area for manipulation and quality control is in seed production. Despite emphasis on artificial cultch and cultchless spat, natural sets make hatchery operations seem insignificant. A light set of 100 to 200 spat per bushel in the Potomac River in 1963 provided five years of excellent oyster production. Cultch was scarce and this level of seed count is considered inadequate for public or private transplant-

ing. Similar spatfalls have occurred in Long Island Sound recently, with dramatic changes in the prospects for the industry. However, a very large percentage (often 90% or more) of seed oysters is wasted or lost by predation, smothering, and mishandling.

Much effort has been spent attempting to adapt the Japanese float and long-line methods of oyster culture. Intensive three-dimensional culture is practical in tidal waters if problems of cost, fouling, and rapid turnover of crops can be solved. In tidal waters extremely dense populations of shellfish may be grown on shell strings or racks of trays. Ponds have rarely been used successfully, for the controlled conditions expected usually are compromised by new problems. Shallow wind-exposed waters and lack of tidal exposure which would help to limit fouling and predators have kept suspension culture from being feasible on the East Coast.

Perhaps the most common mistake is to assume that methods successful in one area or river can be adopted in others. Estuarine ecosystems occur in endless variety. In Long Island, cultchless spat are planted on prepared bottoms at sizes of about ½ inch. In Virginia, blue crabs feast on free oysters less than two inches in length. In 1963, Virginia began dredging buried reef shell, part of which was planted in seed areas as cultch. Five years later the operations ceased with shell reserves apparently depleted except for viable oyster beds. Maryland has planted dredged shells for ten years and appears to have a very large reserve supply. Under the protection of low salinities, Maryland is operating a public fishery that leads the nation in production. Seed production and restrictions on gear are the major limitations on production. It is interesting to speculate what would be done with the oysters that could be produced on now barren bottoms, if private management were allowed to rent and cultivate these thousands of acres of natural oyster grounds.

THE HARD CLAM AND SOFT CLAM OF THE WESTERN ATLANTIC COAST

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This paper describes uses of these clams by Indians, the present fishery, and certain aspects of the ecology of the shellfish.

Indian Uses. The hard clam or quahaug (*Mercenaria mercenaria* and *M. campechiensis*) and the soft-shell clam or manninose (*Mya arenaria*) were prominent in Indian culture as foods and artifacts. Quahaug valves were broken and the pieces ground into cylindrical beads which were strung for trade purposes. In this shell-money or wampum the dark, purple-colored beads were worth twice as much as the white ones. Sections of the crenulated shell margin, when pressed against the moist clay, formed decorative designs on pottery.

Present Fishery. Hard clam production averaged 14.3 millions of pounds of meats per year during the ten-year period 1959–1968. New York, the top

producer, averaged 5.4; New Jersey 2.1; Rhode Island 2.1; Virginia 1.9, and Massachusetts 1.4 million pounds. All others totalled 1.4 with no one state exceeding 0.4. The soft clam fishery, centered in northern New England and Chesapeake Bay, averaged 9.7 millions of pounds of meats a year, 1959–1968. Top producer, Maryland, averaged 6.3, followed by Maine (2.3) and Massachusetts (0.9). Intertidal populations of these clams provide a popular sport fishery in some states.

Soft clams, largely intertidal in the north, are dug by a "hoe,"—a short-handled rake with four broad-bladed tines. In Chesapeake Bay, nearly the entire resource is subtidal and it is harvested by a hydraulic escalator dredge. The hard-shelled clam can be harvested by rougher methods. Hand gear include the "hoe," basket-like scratch rake, bull rake, and tongs. Several types of mechanical gear are used; the dredges commonly are operated hydraulically and utilize water jets to free the clams from the substrate. The hydraulic escalator dredge is the most efficient gear; clams, jetted from the substrate, pass over a horizontal blade of the dredge onto a conveyor belt which brings them up to a tumbling cage from which smaller material drops back to sea before the dredged material is tumbled onto another moving belt for sorting.

Aquaculture of the hard clam is receiving much attention.

Ecological Considerations. Both hard and soft clams live in similar estuarine habitats, sometimes coexisting but not with each in abundance. Their ecology, not fully understood, is obviously somewhat different. Latitudinal distribution is distinct: the soft clam ranges from the Canadian Maritimes to North Carolina; *M. mercenaria* (the northern quahaug) is found principally in the northern portion of the hard clam distribution, from Maine southward, and *M. campechiensis* (southern quahaug), which has commercially-harvested offshore (oceanic) populations, mainly southward, New Jersey into the Gulf of Mexico.

Bivalves characteristically spawn during early summer when the increasing water temperature reaches a spawning-stimulating "threshold" level. After high summer temperatures, spawning may occur again in the autumn as the decreasing temperature passes a "threshold" level.

In laboratory crosses, the two *Mercenaria* species form viable hybrids; their early developmental stages are identical. Spawning can be induced easily in conditioned *Mercenaria*, but not in *Mya*. The early life stages of most bivalve mollusks are similar; only those of *Mercenaria* are described here. Eggs and sperm are discharged into the water. Unlike most bivalves, the eggs of the hard clam have a thick gelatinous envelope. Within 2 hours after fertilization, depending upon water temperature, the 2-celled stage is reached. Other factors such as food, turbidity, and salinity also affect the rate of development. In about 12 hours at room temperature, the microscopic, ciliated trochophore larva emerges from the gelatinous egg capsule. Soon thereafter shell secretion begins and a straight-hinged, shelled larva is formed. As this veliger enlarges, its shell begins to change shape and the umbone stage is reached. All of these stages are planktonic. The next stage is transitional, capable of swimming and of creeping over substrate, attaining an ultimate size which varies considerably, but metamorphosis to the next stage is most common at sizes from 200 to 215 microns in shell length. A true benthic stage results; in metamorphosis the swimming organ (velum) is lost and a

byssus gland becomes active. Byssus production stops at the juvenile stage, when the small clam is about 9 mm. in length.

Growth is step-wise—rapid shell formation with a slower increase in the soft parts. The mantle secretes shell material over its entire surface, creating a laminated structure in which the largest increments of deposition are around the periphery of the shell. This laminated structure must be studied in three dimensions to be fully appreciated. For example, a prominent growth "ring" on the surface of the shell is associated, internally, with a prominent layer of translucent material throughout the entire shell. It marks a time of abrupt cessation of shell formation. This readily visible record results from all-winter hibernation as well as short-term disturbances such as a heavy storm. Normal "biological clock" rhythms probably also are well-recorded in the shell but the magnitude of their record is microscopic and, thus far, inadequately studied. Even so, the sophisticated oxygen-isotope technique enables researchers to determine the water temperature at the time the shell material was deposited—even in fossil shells.

Clams are active burrowers, especially in the younger stages. The shell, water jets, and the synergistic-antagonistic relationships among the hinge, muscles, and hemocoel all play a role in burrowing. It is said that General George McClellan developed the water jet as an aid to sinking piling in sand after having observed clams.

Hard clams have the unique ability to rid themselves of mud even when out of water; a special mucus-secreting area of the mantle enables them to drivel.

The largest reported hard clams reveal the great species difference in shell weight: *M. mercenaria*, 6⅛ inches in length, 2.5 pounds live weight; *M. campechiensis*, 6⅝ inches, 6.5 pounds.

Anomalies in shell shape and soft parts are occasionally reported. Of interest are the asymmetrical shell deviation in *Mercenaria* which is suggestive of the *Exogyra* shape (one deeply cupped valve and the other nearly flat) and a bifurcated intake siphon which apparently may be formed in any species with well-formed siphons.

MINOR SPECIES—BAY SCALLOPS, RAZOR CLAMS, AND MUSSELS

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Three species of commercially valuable bivalve mollusks are presently of minor economic importance on the east coast of the United States.

The bay scallop, *Argopecten irradians*, once supported a fishery surpassed only by oysters and hard clams. Ecological problems (pollution and eel grass disease) have reduced the resource, while economic problems (market competition with other scallop species and unreliable supply) have depressed

the fishery. However, interest in bay scallops has been maintained by State and local agencies so that efforts to improve natural populations are underway and cultural practices are being developed. Intensive management may be instrumental in restoring some of the fishery, but it is doubtful whether the problems of coastal pollution and market competition can be overcome.

Razor clams, *Ensis directus*, are abundant over much of the east coast. The need for efficient catching gear and consumer education are limiting factors that will continue to discourage commercial exploitation. An existing sport fishery for razor clams should be promoted and could provide significant economic and recreational benefits for coastal communities.

The blue or edible mussel, *Mytilus edulis*, possibly holds the greatest promise for an expanded fishery on natural beds and for development of intensive aquacultural production. Rapid growth, byssal attachment, and ease of harvest are desirable attributes. Meat production per unit area is the highest recorded for any commercial animal and a superior meat-to-weight ratio, double or triple that of other commercial mollusks, makes it attractive for industrial processing. Although highly valued in Europe, the mussel has never been widely accepted in the United States. A sizable canning industry was developed during World War II, but disappeared with the relaxation of wartime restrictions. Cultural practices have been highly developed in Europe, notably raft culture in Spain, and this success has influenced other regions throughout the world to attempt mussel culture. The vast mussel resource of our east coast should be exploited and the mussel is recommended for those interested in molluscan aquaculture. The lack of acceptance for mussel meat by the American public should not be limiting since processed specialty products were successful in the past and new products, such as mussel protein concentrate, offer outstanding opportunities for expansion of the fishery.

WEST COAST MOLLUSK FISHERIES[1]

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The overall commercial mollusk fisheries of the Pacific Coast, though minor in comparison to those of the Atlantic Coast or Gulf of Mexico, are substantial and in certain localities are among the leading sources of income. The sports fishery for west coast species, particularly of clams, is far more intensive than in other parts of the United States. The estimated numbers of sports fishermen digging razor clams, for example, frequently exceeds the creditability of persons unfamiliar with the crowds appearing on a Washington beach during an extremely low tide.

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When the first white men settled on the West Coast, extensive beds of native oysters, *Ostrea lurida*, were present from San Francisco Bay through most of British Columbia. The greatest natural abundance was in Willapa Bay and southern Puget Sound in the present State of Washington (Gunter and McKee, 1960). Natural reefs were quickly exploited, beginning in San Francisco Bay during the gold rush of 1849, in Willapa Bay in 1851 (Esveldt, 1948), and in British Columbia in 1884 (Quayle, 1969). In Willapa Bay, the industry peaked in the 1870's, quickly declined in the 1880's, and was abandoned between 1895 and 1906 (Esveldt, 1948). During the latter period, when oystermen in Willapa Bay began importing the eastern oyster (*Crassostrea virginica*), southern Puget Sound continued as an important producer of native oysters. Because of excessive mortalities of eastern oysters, importations of Pacific or Japanese oysters, *C. gigas*, began in 1922. Culture of this species became widespread along the Pacific Coast, relying almost entirely on seed imported from Japan. The State of Washington is the leading Pacific Coast producer, with peak production around 10 million pounds, and averages of about 8 to 9 million pounds over the past 10 years.

Although about 500 species of bivalve mollusks are native to the Pacific Coast, of which 35 are edible, only 9 appear in the commercial market. Most are too small or too infrequently found, or both, to support a commercial clam fishery (Amos, 1966). As Amos points out, the commercial harvest of clams along the Pacific Coast in 1963 was about 5½ million pounds, worth about a half million dollars to the fisherman. The razor clam (*Siliqua patula*), Pismo clam (*Tivela stultorum*), and bean clam (*Donax gouldi*) inhabit the sandy beaches of the open coast, while other species are found in the quiet waters of protected bays and sounds.

By far the most important clam on the Pacific Coast is the razor clam, *S. patula*. Although its range extends from Pismo Beach, California, to the Bering Sea, it occurs in commercial quantities only from Oregon to Alaska. The U. S. catch in 1963 comprised 48 percent of the U. S. Pacific Coast clam fishery and was worth $167,000 to the fishermen. Razor clams are eagerly sought by sportsmen; the Washington effort for the 1967 season (a poor year for clam abundance) totalled 750,000 digger trips. This probably represented a record high for numbers of diggers, but despite an increase of nearly 70,000 diggers (Tegelberg, 1967) the estimated total catch was at about the same level as in 1966 (11.5 million clams).

Although two species of *Saxidomus* — *S. nuttali*, and *S. giganteus* — are recorded, *S. giganteus* from Washington makes up about 99 percent of the U. S. commercial catch for butter clams. In 1963, the U. S. commercial catch totalled 51,000 pounds of meat worth $11,700, while British Columbia produced 684,200 pounds. Alaska contains large numbers of butter clams, but has no viable fishery because of problems with paralytic shellfish poison, harvesting, and processing.

The only remaining commercially important clam fishery is that for the littleneck clam. Actually, two species, one native and one immigrant, are involved. The native littleneck, *Protothaca staminea*, ranges from Alaska to Mexico, but is of commercial importance only in British Columbia and Washington (Amos, 1966). The U. S. catch in 1963 totalled 214,400 pounds of meats worth $107,194, while the British Columbia catch was 32,700 pounds

of meats. The Manila clam, *Tapes philippinarum*, was probably accidentally introduced from Japan long with *C. gigas* seed shipments and is now found from northern California to British Columbia. It competes with *P. staminea* in abundance in many areas, with 32,600 pounds being taken in British Columbia and 119,600 pounds, worth $62,756, in Washington in 1963.

All the above-mentioned clams, as well as numerous other species, are enthusiastically dug by sportsmen. Two species not taken commercially warrant mention. The Pismo clam, *T. stultorum*, from California was once so abundant that it was dug by horse-drawn plows for hog food. Because of overexploitation, the State of California now allows only recreational harvest under strict regulation. The geoduck, *Panope generosa*, is the largest of the Pacific Coast clams, reaching a weight of about 8 pounds, though larger specimens have been recorded. Geoducks are difficult to capture because they are usually buried 3 or more feet beneath the surface. They have traditionally been utilized only by sportsmen, but the State of Washington is considering permits for deep-water commercial harvest with hydraulic dredges.

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THE WORLD CULTURE OF MARINE MOLLUSKS[1]

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Commercial culture techniques for mollusks are relatively primitive when compared to land agriculture. Land agriculture has advanced to a state of complete husbandry of genetically improved stocks, whereas molluscan culture has remained in the more primitive states of wild harvest, wild harvest with control of catch and, at best, only partial husbandry. Obviously, there are fundamental factors producing such a discrepancy.

The answer may be found by drawing a parallel between conditions necessary for species invasion of a new habitat and conditions necessary for "invasion" of a new aquacultural method (Table I). With species invasion there are three necessary conditions. First, the species must be physiologically able to cope with the available niches. Secondly, the niches should be unoccupied by other species. Finally, the potential invading species must have physical access to the niches.

[1] C.B.L. Contrib. No. 442

Table I

A parallel is drawn between conditions necessary for species invasion to new habitat and conditions necessary for advancement of molluscan culture method in a geographical area.

Factors necessary for colonization	
Species invasion	Aquacultural method (species)
Available niches unoccupied	Available area not utilized by more primitive technique
Species physiologically able to cope with available niches	New techniques economically viable in the system
Species has physical access to niches	Enterprise must know of available advanced techniques

Similarly, with invasion or advancement of molluscan culture methods there appear to be three prerequisite conditions (Table I). First, the new methods should be economically viable in the area. Second, the area should not be utilized by another, perhaps more primitive culture method. New developments are quite often seen as a threat to security. This leads to resistance to any change. Finally the people who undertake the new methods in an area must know of the advanced techniques in order to try them.

Thus, the state of development of molluscan culture can be viewed in terms of these rather fundamental factors. There are many examples of wild harvest (i.e., surf clams of the Atlantic coast) simply because a more advanced technology is not economically workable. In most areas molluscan culture has advanced to partial husbandry; none, to my knowledge, to complete husbandry. For convenience, I shall describe three examples of the partial husbandry of oysters. These are Japanese raft culture of *Crassostrea gigas*, and the culture of the American oyster, *C. virginica*, on Long Island Sound and in Maryland Chesapeake Bay. Each is in a different state of development and, considering basic factors, each has a different potential to advance.

Japan has the finest examples of the partial husbandry of oysters, with production of about 35,000 tons of shucked oyster meats annually—this is about 1.5 times that of the entire U. S. annual production (Ryther and Bardach, 1968). To give an idea of the intensity of production, in Hiroshima Bay an annual production of 20 tons of meats per acre by rafting techniques has been reported (Anon., 1968). At that rate, the entire Maryland oyster crop of 1967–68 (500 sq. miles of charted oyster bottom) could be matched in less than one square mile (Anon., 1969). The Japanese production has been enhanced through use of rafting techniques which have become very prominent since World War II, bamboo rafts in protected bays and the newer long line technique in exposed waters. It appears that the principal chance for advance might come with the development of genetic stocks by hatchery production, or by hatchery production and commercial use of other species.

Research efforts are beginning in this direction, an example being the Oyster Research Institute at Kesennuma, Japan, established by Dr. Takeo Imai in 1961. By a system of outdoor tanks, they have been able to rear in the hatchery the European flat oyster (*Ostrea edulis*), Portuguese oyster (*Crassostrea angulata*), American oyster (*C. virginica*), Olympia oyster (*O. lurida*), Japanese deep sea scallop (*Patinopecten yessoensis*), northern Japanese abalone (*Haliotis discus*), California red abalone (*H. rufescens*), and the arkshell (*Anadara broughtoni*). All present techniques are prohibitively expensive for commercial application; however, any new technology is initially expensive.

Long Island Sound, in Connecticut and New York, is an oyster producing area which presently satisfies all of the conditions which seem necessary for advancement of culture technique. Before the 1950's, there was a thriving industry based on a system of public and private seed beds, mainly on the Connecticut shore, coupled with growing areas mostly on the Long Island shore. There was then a precipitous decline from a yearly average of about 1,300,000 bushels in 1950–52 to about 40,000 bushels in 1967 (MacKenzie, 1970). The decline was caused by a drastic reduction in natural seed production attributed to several factors including a disastrous storm in 1950 which disrupted existing seed beds, low availability of cultch shells due to loss to the half-shell trade, and increased starfish predation after 1957 (MacKenzie, 1970). Thus, the potential shellfish growing areas are presently not being fully utilized. Presently, Long Island-grown, half-shell trade oysters are fetching about $18 per bushel on the market (much higher than the $5 per bushel for Chesapeake stocks). Thus, any successful technique to produce Long Island oysters should be highly profitable.

With this circumstance, there have been several noteworthy developments. The introduction of large scale investment capital has resulted in the consolidation of many smaller companies into larger units. This has meant that organized research and development capital can be focused on technique advance. There has been greatly renewed interest in the hatchery method of culturing oysters originally begun at the Bluepoints Company, Great South Bay, by Wells and Glancy (see State of N. Y. Cons. Dept., 1969).

In 1968, there were four operational hatcheries on Long Island and one in Connecticut attempting to produce seed economically by the new cultchless setting methods. This, coupled with basic genetic investigation and possible development of superior strains of oysters at the U. S. Bureau of Commercial Fisheries Laboratory at Milford, Connecticut (Longwell, 1970), has created a real basis for potential advance to the full husbandry of shellfish. Advancement of on-bottom culture technique is another noteworthy development in the Long Island Sound area (MacKenzie, 1970). By the use of SCUBA diver observation, the methods and timing of bed maintenance are vastly improved. MacKenzie predicts that the old 1-for-1 yield (bushels of harvest for bushels of cultched spat) can be improved up to 20-1 by these techniques. The Long Island area appears to have excellent potential for advance to complete husbandry.

The Maryland Chesapeake Bay area, although it has undergone great decline in oyster production from historic highs (from a yearly harvest of 16 million bushels in the early 1900's to about 3 million bushels presently), has a different and lower potential for advancement. Early in the century, in

contrast to other areas, Maryland retained the public ownership and management of its oyster bars, which included about 400,000 acres (95%). The resource is managed by the Maryland Fish and Wildlife Administration and fished by some 4,000 licensed watermen. While significant and productive efforts in public management have helped to double production in recent years, the inherent constraints hold down the potential. The Maryland oyster fishery has been cited by Glude (1966) as an unsuccessful fishery under several economic criteria. Moreover, Glude states that Maryland oyster production could be increased from the present 3 up to 40 million bushels per year with the implementation of the best available technology. The reason, perhaps, for the low production figure is that the management agency and the watermen in effect are occupying the "oyster producing niches" in the Chesapeake Bay. The public agency must listen to the wishes of the watermen, who are by nature conservative. New innovations of the department that may materially depart from traditional ways are looked upon as threats to livelihood, and political pressure is applied to keep the status quo. The result of this interaction has, to my mind, resulted in a very low political potential in Maryland Chesapeake Bay for advances in the culture method. The biological potential remains high.

To conclude, it is obvious that most of the world molluscan fisheries are presently operating at a relatively primitive state, vastly under their productive potential. It is also obvious that the advance of shellfish culture to full husbandry would greatly enhance the world's available protein supply.

However, there are many cultural and aesthetic values present in many of our primitive fisheries that may be lost with advancement. The Maryland watermen, for example, are a very close-knit, independent and able breed that is all too rare in America today. The restriction in the Maryland Chesapeake Bay to sail dredging has allowed preservation of the last working sail fleet in the United States. These are very real values that might be destroyed with modernization, in a land where mass production has not brought universal good. In summary, the world molluscan fishery could operate on a more sophisticated and productive basis. We should first learn of the positive and negative values that might result from this before giving our unqualified blessing.

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SURF CLAMS AND OCEAN QUAHOGS

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Surf clams, *Spisula solidissima*, and ocean quahogs, *Arctica islandica*, have been intensively sampled in the middle Atlantic continental shelf to delineate their distribution and density. A hydraulic surf clam dredge sampled an average of 53.8 square meters of bottom at each station during a 5-minute tow; the stations, located 5-nautical miles apart, formed a grid within each of four geographic sample areas used in discussing the results. A scale, rating the importance of each area based on clam abundance, was derived from an analysis of the numbers of bushels taken per station, the numbers of clams caught per station and their shell lengths, and estimates of the standing crop in 1965 (Table I). The average and range of water depths where the clams were found is also given.

The relative importance of geographic sample areas has recently changed because increased fishing activity in the New Jersey area has removed almost 200 million pounds of meats since 1965—this area now would be rated second to the Delmarva Peninsula area. Some of the fleet has moved to beds in the Delmarva Peninsula area and this effort has maintained a high level of production. In 1969, total landings reached a record high of 49.6 million pounds of surf clam meats.

Ocean quahogs, an underutilized resource, are very abundant in the Long Island and New Jersey areas. Dense beds are at depths of water well within the operating limits of the hydraulic surf clam dredge. A small fishery in Rhode Island landed 472 thousand pounds of meats in 1969, which is a significant increase over annual landings of less than 100 thousand pounds during the past decade.

During the 1965 survey, most surf clams were taken from near-shore water to depths of 43 meters; most ocean quahogs were farther offshore at depths of 25 to 61 meters (Fig. 1). Surf clams were taken most often at an average depth of 28.5 meters and ocean quahogs at 41.7 meters. Mixing of both species was most pronounced between 24.5 and 42.7 meter depths. Both species occurred in deeper water and farther offshore at the southern end of their range than at the northern end (Table I). Greater bathymetric records have been reported for both species. The numbers of surf clams taken, however, were low and the shell lengths small. Only the ocean quahog may have significant populations beyond the limits of the 1965 survey.

Materials extraneous to the catch of clams in the dredge indicated that mollusk shells are a significant part of the bottom substrate. Invertebrates often taken in the samples, such as the moon-shell snail (*Lunatia heros*), rock crabs (*Cancer irroratus* and *C. borealis*) and asteroid starfish (*Asterias* sp. and *Astropecten* sp.) were recognized as predators of the clams. Small-sized invertebrates, such as *Astarte* sp. and *Prunum apicinum*, suggested that the

Table I

Survey results for *Spisula solidissima* and *Arctica islandica*—1965.

Geographic Sample Areas	*Spisula soldissima*			*Arctica islandica*		
	Abundance Rating	Depth in Meters Average	Depth in Meters Range	Abundance Rating	Depth in Meters Average	Depth in Meters Range
Long Island	3	21	6.2–48.9	1	39	18.4–61.0
New Jersey	1	29	12.3–61.0	2	40	18.4–61.0
Delmarva Peninsula	2	30	12.3–67.2	3	45	24.5–73.4
Virginia-N. Carolina	4	32	12.3–61.0	4	52	36.7–67.2
Grand Average	–	28.5	6.2–67.2	–	41.7	18.4–73.4

dredge would take small surf clams and ocean quahogs. However, no surf clams 30 millimeters or less in shell length were caught and most were more than 100 to 166 mm. long; no ocean quahogs less than 30 mm. long were taken and most were more than 75 to 105 mm. long.

From studies of surf clam biology, it is known that populations off New Jersey can spawn twice in a year. A major spawning occurred in mid-summer followed by a minor spawning in late fall during three of the four years samples were taken. Only a single, late summer spawning occurred during the fourth year. Bottom water temperatures greatly influenced gonadal development. A single hermaphroditic surf clam was found in a sample of 2,500 examined. Larval development through metamorphosis was completed in 19 days at 22°C in the laboratory. A haploid chromosome number of 18 was

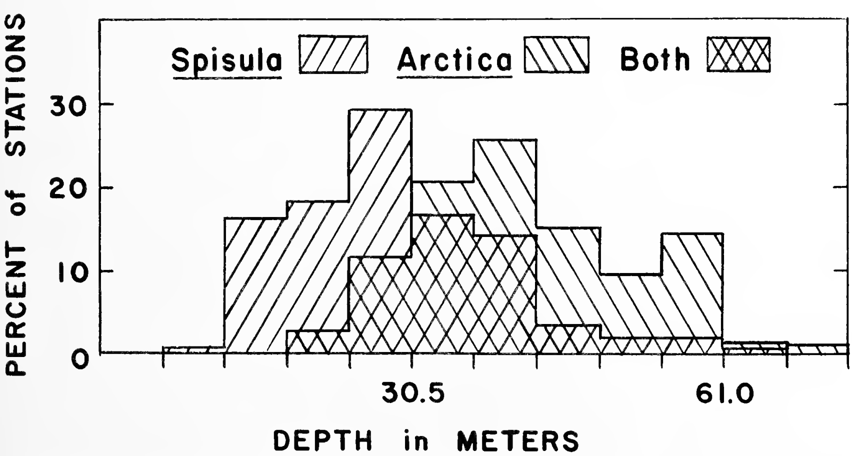

Figure 1. The distribution of *Spisula solidissima* and *Arctica islandica* by depth in the Middle Altantic Bight—1965. (30.5 m. = 100 ft.)

determined from stained squashes of surf clam eggs. Through marking experiments, an adhesive was found to attach streamer tags to the shells and notching techniques were developed to observe clam growth. From our observations of growth during the early life of a surf clam, those 5 to 6 years old generally exceed 100 mm in shell length and are recruits to the fishery. Surf clams are very active burrowers and can disappear within 2 minutes after penetrating the foot into bottom substrates. Leaping from the bottom and crawling over the bottom are two other locomotor activities. In the surf zone, the clams are ineffective against the greater physical forces of wind and waves. Many are washed ashore to die, others are easy prey for shore birds.

THE SEA SCALLOP

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The scallops, even more than the oysters, appear in the relics and records of mankind's antiquity. The stylized scallop shell motif reappears constantly in classical, medieval and renaissance art and architecture—most notably in Botticelli's painting of the goddess Aphrodite rising from the sea. It is safe to venture that when an inlander thinks of a seashell, he unconsciously visualizes a scallop with the beautifully contoured, ridged valve. The sea scallop (*Placopecten magellanicus*) does not fit this idealized picture because of the rather smooth shell, but it is one of the largest scallops in the world, and unquestionably the most valuable commercially.

In the U.S. the sea scallop harvest ranks third in volume, but second in value among the bivalve mollusks—surpassed in total value only by the oyster and ranking slightly higher in value than the oyster per pound of meats. As an example of its value, in 1968 U.S. scallopers landed a total of 14.1 million pounds of shucked meats worth 15.7 million dollars at dockside. U.S. production reached its height in 1961, when total landings exceeded 27 million pounds of shucked meats.

Sea scallops are found on beds of gravel, sand or pebbles, usually mixed with shell. They have rows of functioning bright blue eyes, which line the edges of the mantle, providing a stimulus for movement and escape from predators. The most unique feature of the scallops is their mobility, which is retained beyond the normal pelagic larval life and throughout adulthood. Swimming is accomplished by jet propulsion, water jets being produced by filling the mantle cavity with water and expelling it through two peripheral openings by vigorous contraction of the valves. However, while individuals are quite mobile, tagging experiments indicate that populations do not migrate to any extent.

Sexes of the sea scallop are separate, although rare hermaphrodites occur. The gonads ripen during the summer and spawning occurs from late summer

to early fall. Fertilization and larval development are similar to other bivalve mollusks. Metamorphosing larvae sink and attach themselves to various solid substrates by byssal threads, appearing to favor bryozoans and other branching forms of life for anchorage. The byssal attachment can be released at will and the young scallop can move on so seek more favorable sites. Growth is fairly rapid, and by the second year the shells average over 1½ inches in diameter. Commercial size is reached in 4 years at almost 4 inches in length. Occasionally very large sea scallops have been reported with an estimated age of 18–20 years and a diameter of about 9 inches.

Although the normal exigencies of larval and juvenile life take their toll, predation, parasitism and disease do not appear to impair the recruitment of the species—except for the predation by man. Boring sponges and worms damage the shells and probably weaken the mollusks; bottom-feeding fishes consume young scallops; but no lethal epizootic organisms are known. Where mass mortalities do occur they are most likely attributable to deleterious environmental changes—particularly increased water temperatures.

The sea scallop, as its name implies, is an inhabitant of relatively open oceanic waters. It ranges from the Gulf of St. Lawrence to Cape Hatteras. Aside from the major offshore concentration on Georges Bank, scattered but substantial coastal populations are found in the Gulf of Maine and off the mid-Atlantic coast from Cape Cod south to the Virginia Capes. Sea scallops are intolerant of temperatures above 68° F and their entry into salt bays and estuaries, as well as the southern limits of the range, are doubtless circumscribed by temperature. In Maine and Canada, they are present in cold and saline inland waters, like Passamaquoddy Bay. In the northern portion of the range, scallops may occur in relatively shallow beds, while southern concentrations exist in deeper beds, where the water remains cool.

The sea scallop fleet consists of comparatively large vessels, about 85 to 100 feet long, diesel-powered and seaworthy. Fishing is carried on 24 hours a day during 8 to 10 day cruises. The 10 to 20 man crews are divided into 2 six-hour watches for the duration of the trip. The scallop dredge consists of a heavy metal frame mounted on runners and a bag knit of steel rings with a 3 inch inside diameter. Dredge tows are usually 20 to 30 minutes long, depending on the abundance of scallops. Two dredges are towed simultaneously. The dredges are hauled up and the contents dumped on deck and culled. Scallops are shucked on deck, the meats washed in seawater, packed into clean muslin bags holding about 40 pounds, and stored under ice. The bulk of the yield is stored frozen until sold to restaurants and retail markets in raw form. An increasing percentage is processed into precooked convenience foods, such as TV dinners, which are, in turn, frozen for retail sale.

Distribution surveys have effectively delineated the areas of commercial abundance. Since the fishery is to a large extent in international waters, resource management is both physically and politically difficult. Control, such as does exist, is exercised by the International Commission for the Northwest Atlantic Fisheries.

From almost nonexistence before World War II, the sea scallop fishery has expanded to become one of the most economically important offshore fisheries of the New England area. Remarkable increases in landings resulted

Table I
Trends in the Atlantic Coast Sea Scallop Fishery, as Shown by Fishing Effort and Average Annual Landings

Years	Fishing Effort* U.S.	Fishing Effort* Canada	Average Annual Landings (Millions of Pounds)
51–53	12.6	0.8	21.5
54–56	12.9	1.3	21.9
57–59	11.8	2.0	25.3
60–62	10.1	3.7	36.7
63–65	8.8	8.1	35.4
66–68	7.8	9.5	28.0

* Equals thousands of days per year fished

when larger fishing vessels began fishing further offshore and remaining on the grounds for several days at a time before returning to port. Most of the production, averaging about 85% of the total over the years, comes from the relatively restricted offshore area of Georges Bank. Minor landings, usually about 10% of total production, occur at several ports along the middle Atlantic coast. Small numbers of sea scallops are taken along the coast of Maine, at Cape Cod, and at other inshore coastal areas.

Sea scallop production reached its height during the early 1960's (Table I). During this time, Canada built or diverted many vessels to the main scallop fishing grounds until now she controls a fair share of the fishery. Successful populations of sea scallops on Georges Bank have maintained the fishery for years at a high level of production. U.S. production there reached its height in 1961 when 23.6 million pounds of shucked meats were landed. Since then U.S. landings have declined as Canadian competition has increased. This is easily seen through the increase in Canadian effort through the years 1951 to 1968 (Table I). In the early years the U.S. had a commanding lead in fishing effort which has gradually dwindled to about two-thirds of its former strength. During the same period the Canadians have risen from almost no effort to a point where their effort exceeds the U.S. This is reflected in total landings, and Canada now commands better than half the market. Near the height of production the price of landed scallops reached such marginal levels that vigorous marketing campaigns were necessary to make a larger portion of the consumer public conscious of this delectable product.

Most of the U.S. fleet is based at New Bedford, where the catches are sold at auction. Nearly all of the Canadian catch is exported to the U.S. In evaluating the actual size of the catch it should be borne in mind that only the large adductor muscle, perhaps one-third of the shell contents, is utilized for food, while the rest is discarded. The harvests quoted above include only the shucked adductor muscles.

In 1965 sea scallops on Georges Bank were somewhat less abundant than usual and fishermen looked elsewhere for concentrations of sufficient densities

to merit exploitation. Populations were found off the middle Atlantic coast in aggregations strong enough to warrant heavy fishing, and in the second half of 1965 the entire U.S. scallop fleet diverted to this area (mostly offshore of Chesapeake Bay, Virginia, and near the Hudson Canyon, off New Jersey). Some of the Canadian fleet also fished the area during this time. The fleets had great success here which resulted in a significant change in the landings picture. For the first time in the years that Georges Bank had been fished, a greater part of production was landed from other areas (6 million pounds from Georges Bank; 13.9 million pounds elsewhere).

The 1965 (and longer) windfall of sea scallops from the middle Atlantic area gave Georges Bank, an area heavily fished for years by both U.S. and Canadian scallop fleets, a much-needed chance for recuperation of scallop densities. Since 1965, the U.S. fleet has continued its main efforts on the mid-Atlantic stocks, while Canada has steadily increased its efforts on the traditional grounds. This diversion of effort between the two countries has helped to maintain relatively high total landings. Georges Bank will remain the main scallop grounds over the years because of the proven ability of these stocks to continuously repopulate themselves. However, when a scarcity of scallops exists on the Banks, the middle Atlantic will continue to produce "reserve stocks," in areas not predeterminable, that can be drawn upon in times of stress. Total sea scallop production has probably already reached its maximum level of sustainability and should remain as it has over the past few years with minor fluctuations.

THE CALICO SCALLOP: FISHERY AND RESEARCH DEVELOPMENTS

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The calico scallop, *Argopecten gibbus*, is found in open marine waters throughout the Gulf of Mexico and in the western North Atlantic from off Delaware Bay to the northern side of the Antilles. This scallop has been taken in depths of 5 to 200 fathoms with a bottom water temperature range of 14° to 33°C. This species is usually found in abundance on sand-shell bottoms near prominent coastal projections.

The largest population of calico scallops thus far discovered is in the Cape Kennedy area off the east coast of Florida in depths of 10 to 40 fathoms. Smaller, less stable populations of commercial importance are found off Cape San Blas in the northeast Gulf of Mexico and in the Cape Lookout area off North Carolina.

The development of efficient shucking and eviscerating machinery has made harvesting this small (50–65 mm in shell height) scallop economically

feasible. Scallops as small as 45 mm in height are acceptable for machine processing. Commercial quantities of calico scallops with a shell height greater than 70 mm are uncommon—maximum size is about 80 mm.

Calico scallop concentrations are considered commercially significant if a 30-minute tow with an 8-foot tumbler dredge will produce 40 or more pounds of scallop meats.

Converted shrimp trawlers, scallop draggers, and specially designed 85-foot factory-type vessels have been used to catch calico scallops. Shellstock on the Cape Kennedy and Cape San Blas beds is generally taken with 8- or 10-foot scallop tumbler dredges, while in the Cape Lookout area, recently designed and highly efficient scallop trawls are preferred.

At present there are two trends in the calico scallop fishery: that of using a factory-type vessel to machine-process the catch at sea, and the use of catcher boats to supply shellstock to shore-based processing houses.

Commercial production has fluctuated widely for a variety of reasons. High seas, hot weather, malfunctioning of processing machinery, and shellstock availability have influenced production rates to some degree in all areas of the fishery.

The Bureau of Commercial Fisheries is monitoring the calico scallop stocks through resource assessment and biological research.

The assessment program is being conducted by the Exploratory Fishing and Gear Research Base, Pascagoula, Miss., by means of transect dredging, observations from submersibles, and more recently, by use of a bottom-viewing device called RUFAS (Remote Underwater Fishery Assessment System). RUFAS is a remote controlled underwater sled containing a TV and underwater motion picture camera. The towed sled is maintained about 5 feet off the bottom and is steered by the towing vessel. As the sled passes over the scallop beds, continuous or intermittent motion pictures or video tapes are taken of scallop concentrations. This information is plotted and made available to the scallop industry. Scallop densities exceeding 8 per square foot have been recorded by RUFAS on the Cape Kennedy beds.

Biological research on the calico scallop is being conducted by the Tropical Atlantic Biological Laboratory, Miami, Florida. Studies on spawning, larval development and dispersal, spat set, age, growth, movement, mortality, and environmental factors affecting the scallop beds are in progress.

Calico scallops have been spawned in the laboratory, and the larvae reared to the veliger stage.

Two offshore study sites have been established on the Cape Kennedy scallop beds as this animal is one almost ideally suited for study by direct observation. At these locations, SCUBA divers have installed spat collecting devices, current and temperature recorders, and they have placed marked[1] scallops on the bottom for age, growth and movement studies.

It is anticipated that the underwater study sites will answer many basic questions about this new and valuable resource.

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[1] The shell marking agent used is All-Crete, a quick-setting cement that hardens underwater. A paper entitled "Marking Mollusks with Quick-Setting Cement" is in manuscript and will be published in the near future.

HISTORY AND CURRENT STATUS OF THE SUNRAY VENUS CLAM FISHERY IN NORTHWEST FLORIDA

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A new fishery was initiated in February 1967 near Port St. Joe, Florida, for the sunray venus clam, *Macrocallista nimbosa* (Solander). This marked the first commercial harvest of this species and was accomplished under a permit issued by the Florida Department of Natural Resources (then the Florida Board of Conservation) which required that a Department biologist accompany the clam vessel during the first few months of harvesting. Thus was realized a very rare opportunity: to observe the initial utilization of a virgin resource.

Mr. George Kirvin, owner of Quality Seafoods of Apalachicola, Florida, discovered this rich bed of sunrays and modified his 65-foot shrimp trawler to harvest his discovery. Originally Mr. Kirvin equipped his vessel with a 27-inch "Nantucket" dredge, which uses water pressure (provided by a 1,000 gallon-per-minute pump driven by a large deck engine) to dig the clams and force them back in to the metal catch container. The entire unit (dredge, water hose, and clams) is then lifted onto the deck with an "A" frame, emptied, and returned overboard to continue fishing. A tow time of 10 to 15 minutes was preferable, preventing overfilling of the dredge and undue breakage of clams.

The biologist participated in 50 harvestings trips (days) during February, March, April, May, and June 1967. The average number of bushels per 10-minute tow during each month ranged from 2.5 to 8.7 and the average catch per day for each month ranged from 109 to 331 bushels. The largest single day's catch was over 570 bushels and the total catch was approximately 10,300 bushels.

Clams on the grounds were quite uniform in size, averaging about 130 mm in length, and preliminary growth studies indicated that these animals may be as much as four or five years old. These data also implied that growth was much more rapid in the smaller clams and that a length of almost three inches might be possible in their first year.

In contrast to the rather uniform length found on the fishing grounds, catch lengths with the same gear in inshore (shallow) waters ranged from 25 to 130 mm. The dominance of smaller clams inshore and the completely opposite situation offshore suggest a movement of young adults from the inshore areas to the offshore fishing grounds.

This fishery is continuing and although many advances have been made since those first months of harvest, problems still exist. The most significant is the apparent small size of the fishing grounds. There are now two vessels with 60-inch dredges which fish the grounds, catching from 150 to 400 bushels each per day. A bushel of clams brings $1 to the boat, an amount which is divided among the three crew members (15¢ each) and the vessel (55¢). At the fish house, one bushel yields 9 to 11 pounds of cleaned, shucked meats which sell for 28¢ per pound.

Even though there is not yet any concrete evidence of a decline in the fishery, the fishermen themselves are concerned and would like to find new beds with the same high concentrations of clams. Because of this need our Marine Research Laboratory outfitted its research vessel, the *Hernan Cortez* (a 72-foot St. Augustine shrimp trawler), with an "A" frame and Nantucket dredge.

Exploratory sampling in depths from 15 to 70 feet has been accomplished from Apalachicola to Pensacola and is now continuing in the Cedar Key area. Thus far extremely heavy populations, such as those in the Port St. Joe area, have not been encountered, but the samples are by necessity rather widespread and the area is extensive. Catches near Fort Walton Beach and Cedar Key were relatively good, however, and following completion of the broader sampling, work will be concentrated in areas showing the most promise.

In addition to the strictly exploratory efforts, valuable data are also being obtained on the occurrence, distribution, abundance, and bathymetric range of the sunray venus. Work has already indicated that these clams are restricted almost entirely to depths of 35 feet or less and that the greatest concentrations occur in quartz sand. Records are being maintained on the species diversity and abundance of all other fauna taken in the Nantucket dredge. Size is recorded for selected species which have commercial possibilities and many specimens are retained for the invertebrate reference collection.

Marking studies have been continued to obtain more data on growth rates and to determine if there is a movement of animals from inshore to offshore.

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CEPHALOPOD RESOURCES AND FISHERIES IN THE NORTHWEST ATLANTIC

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Recent harvesting of major groundfish species at or beyond maximum sustainable yields emphasizes the need to diversify fishing efforts in the Northwest Atlantic. Cephalopods comprise an underexploited resource here as in many other areas, the region herein considered being that from Cape Hatteras to West Greenland (the ICNAF convention area). For data on the Caribbean and northeast Pacific the reader is referred to Voss (1959) and Fields (1965) respectively.

While there are many species of cephalopods in the oceanic zone (see Mercer, 1968) only a few are accessible to standard fishing gears inshore and

on the continental shelf. The oegopsid *Illex illecebrosus* and myopsid *Loligo pealei,* squids presently exploited commercially, offer far more potential for an expanded fishery than do other forms; only these species will be considered although the possibilities of future oceanic fisheries are not to be dismissed (see Clarke, 1963).

Illex illecebrosus. This ommastrephid is a seasonal migrant to Newfoundland waters where it is fished from about mid-July to late October or early November each year. It occurs inshore sporadically southward to Cape Cod but south of there it is generally restricted to the continental shelf and slope. For data on its biology see Squires (1957) and Mercer (1965).

The Newfoundland fishery is passive in that it is based entirely on availability of squid to jigging devices in inshore waters of less than about 20 meter depth. Fluctuations in catch thus reflect variations in local distribution in relation to environmental parameters and variation in behavior with regard to jigs; also the northern extent of the summer distribution varies yearly. It is clear that Newfoundland landings could not be taken as an accurate index of population sizes even if fishing effort were constant.

Since the species is presumably monotelic and probably lives only one or two years (see Squires, 1967), wide fluctuations in stock sizes are to be expected. The short life span and single year class entering the fishery preclude anything but short term prediction of stock size for any given year class, even with hitherto unavailable data on abundance and mortality of young juveniles. No cycle or correlations of abundance with environmental parameters have been demonstrated. However a rough correlation between catch rate of the northward migrant squid on the southwest slope of the Grand Bank in May and June and subsequent inshore landings allows for a crude forecast shortly before the fishery commences (Squires, 1959).

Recent annual landings at Newfoundland have ranged from nil to 10,500 metric tons, most of which is exported to Norway and Portugal for use as cod bait. In years of abundance, the resource inshore is enormous. At an average weight of 830 kg. (Sergeant, 1962) and a feeding rate of 4–6% body wt/day (extrapolated from congeners, data from Sergeant, 1969) the 10,000 pilot whales (*Globicephala melaena*) taken on the east coast of Newfoundland in 1956 alone would eat approximately 33,000 to 55,000 metric tons of squid in a 100-day season. (This odontocete feeds almost exclusively on *Illex* in Newfoundland inshore waters—Sergeant, 1962.) This is 4–5 times as great as the largest squid catch in one season for all of Newfoundland, indicating that fishing mortality is a small percentage of total mortality for squid in this area.

Loligo pealei. This neritic loliginid is most abundant from Cape Cod to Cape Hatteras. In winter the population is most concentrated just below the shelf break of the mid-Atlantic Bight (Summers, 1969; Vovk, 1969; Mercer, 1969b) where it is accessible to the trawl fishery; the larger squid generally migrate deeper. Diurnal variation in availability to otter trawls indicates vertical dispersal at night (Summers, 1969). Summers estimated late winter abundances in the Bight at 3.4 and 2.1×10^6 kg. respectively for 1967 and 1968

but, as he noted, these figures are extreme underestimates and are of minimal population sizes since the sampling time was just prior to the breeding season.

Vovk (1969) analyzed 3,420 trawl sets made from Georges Bank to Cape Hatteras by vessels of the Soviet *Atlantniro* in 1958–1968. He reported largest catches in June-November northeast of Blake Canyon. Catch per hour averaged 0.5–1 metric ton and ranged to 6 tons on the southern slopes of Georges Bank. Catches of 25 tons were made in 60–100 meters off Wilmington, Delaware and Baltimore, Maryland, abundance in a 30 square mile area off Wilmington being estimated at 6–7,000 tons.

In December 1969, Japan commenced trawling for squid off New York with 14 vessels; the number of vessels dropped to 6 in April because of decreasing catches. Landings to April were estimated at 13,000 metric tons, these being sold in Europe (Anon., 1970). Spain, the largest buyer, is reportedly planning to fish squid in the same area during the 1970–71 season.

In summer, squid from the Bight migrate up to 600 miles north and 200 miles inshore (Summers, 1969) where breeding occurs, and here they are taken by various inshore gears from about mid-May to mid-November. Recent annual landings have averaged about 1,500 metric tons (see Lyles, 1968).

Discussion and conclusions. Northwest Atlantic cephalopods are presently being exploited at levels far below maximum sustainable yields. However it is likely that the fishery will expand rapidly in the next few years and long term investigations on population structure and dynamics are required to assess the effects of more intensive fishing on the stocks. While some progress has been made in characterizing *Illex* stocks by size distributions, maturities and parasites (Mercer, 1969a, and in prep.), in the author's opinion, population genetic studies utilizing protein polymorphisms offer greatest promise in this regard.

Since fecundities are high, natural mortalities must be correspondingly high and, from experience with teleosts, one would intuitively hypothesize that the difference between good and bad year classes is established by density-dependent and environmentally related mortality in early stages. Gulland (1965) argued convincingly (for teleosts) that understanding of happenings in early stages will accrue from normal population dynamic techniques rather than from correlation studies with environmental parameters. This indicates another important direction for research on *Loligo*; the early life history of *Illex* is hitherto undescribed.

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CONCH FISHERIES

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The term "conch fishery" usually is taken to apply to the commercial catch of the knobbed and channeled whelks, *Busycon carica* and *B. canaliculatum*, along the eastern seaboard of the continental United States, although the term "conch" is frequently used in reference to any of the large prosobranch gastropods, particularly in the families Strombidae, Cassidae, and Galeodidae. The recorded landings of all gastropod mollusks utilized for commercial purposes in America are herein considered as conch fisheries. In addition to *Busycon*, the fisheries for *Littorina* and *Thais* along the coast of Maine, and for *Haliotis*, the abalone, are the only significant enterprises to bear attention.

Fishery Statistics of the United States, an annual report published by the Bureau of Commercial Fisheries of the Department of the Interior, is the principal source of data on the commercial catch of conchs in the continental United States. In the West Indies, including Puerto Rico and the Virgin Islands, *Strombus gigas* is marketed for human consumption (Doran, 1958). Since the stromb-fishery in the Bahamas at one time was worth nearly a quarter of a million dollars a year, it has been suggested that this species is particularly suitable for farming (Randall 1964; Iversen 1968). Finally a brisk trade in shells as collectors' objects is maintained in this country and,

though few data are available, it has been estimated by the Commerce Department that over $15,000 worth of shell-trinkets and related objects are imported into Florida from the Bahamas each year (Boss, 1969).

The shell fishery for conchs in the United States consists of a minor commercial venture in comparison to the fisheries for scallops, soft-shelled clams, and quahogs. Presently only three processing plants (New York, New Jersey, and Delaware) handle the commercial catch along the eastern coast; elsewhere conchs, limpets, periwinkles and the like are sold directly in markets or are served in specialty restaurants, particularly Chinese and Italian.

The conch-fishery for *Busycon* in the New England (Massachusetts, Rhode Island, and Connecticut), the Middle Atlantic (New York and New Jersey) and the Chesapeake (Maryland and Virginia) regions varies greatly from year to year. During the last ten years, 1966 was a peak period with over a million pounds of conchs harvested along the eastern Seaboard. The year 1963 was good in the Middle Atlantic Region with over a half million pound catch, and 1962 in the Chesapeake Region with more than 400,000 pounds. In 1966 in the South Atlantic Region (North and South Carolina, Georgia and eastern Florida) the best prices were fetched, about 38 cents/lb., though the catch was only 310,000 pounds. The price per pound varies from state to state and usually the best prices are paid in the Middle Atlantic Region (between 22 and 25 cents/lb.). In general, there has been an upward trend in the *Busycon* fishery. Prices per pound as well as the annual catch have increased slightly during the last ten years.

In Maine, a small fishery for *Littorina* and other rock dwelling gastropods, *Thais* and *Acmaea*, exists and the annual harvest averages 50,000 pounds with a commercial value near $12,000.

Probably the most important gastropod fishery in the United States is in California where several species of *Haliotis* are taken commercially for a total annual value of nearly $1.5 million after processing. Recently this fishery has been threatened by overfishing and the return of the sea otter; some areas, which supported an active industry with many divers and vessels, have recorded a marked reduction in the fishery during the last ten years (Turner, 1970).

Since the conch-fishery in America is relatively small, the potential for an expanded industry is considerable. Several foreign nations, notably India and Japan, have substantially larger fisheries for marine gastropods. As world food resources dwindle in the face of greater demand, and as the tastes of gourmets grow to include these delicacies, the conch-fishery might be considered as an expandable industry in mariculture.

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PREDATORS AND DISEASES OF COMMERCIAL MARINE MOLLUSCA OF THE UNITED STATES

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Among the many environmental factors preventing the full expression of the biotic potential of commercial marine mollusks are predation and disease. These two factors are partially density dependent, and may at times be dominant influences on population size of commercial species.

The more important predators of marine Mollusca are starfish, flatworms, predacious and parasitic snails, crabs, fishes, and cephalopods. The importance of a number of these predators—particularly starfish, crabs, and fishes—has been well established, but there have been recent developments of interest with certain other predators. Although known for at least 60 years as oyster pests, it is only recently that the very serious predation of polyclad flatworms on oysters has really begun to be appreciated. Entire sets, especially of cultured oysters, may be completely destroyed by these flatworms. Problems with drills have recently been intensified by continuing promiscuous transfers and introductions of commercial mollusks, since existing inspection systems are inadequate to prevent simultaneous introduction of predators, parasites, and pathogens.

A number of animals best described as epibionts or competitors can have severe effects on growth and survival of commercial species. Mud blister worms—small annelids—are damaging pests of oysters, while barnacles, tube worms, and corals can reduce survival of calico scallops. With these animals as well as with predators and parasites, population explosions—periodic and possibly even cyclic—place severe stresses on populations of commercial Mollusca, undoubtedly producing some of the population crashes that have occurred in the commercial species.

Diseases of mollusks, especially of oysters, have received recent attention because of destructive epizootics and resulting mass mortalities. Four diseases have been demonstrated to cause mortalities in American oysters—Malpeque Disease, Delaware Bay Disease, Seaside Disease, and Dermocystidium Disease. Major economic losses have resulted from outbreaks, and control measures are still relatively ineffective. Recent developments in other disease areas include increasing reports of neoplasms in bivalves, and studies of nematode parasites of scallops and abalones.

Few of the diseases of mollusks are transmissible to humans, but there are a number of human diseases that result from passive transfer or accumulation of chemicals or pathogenic microorganisms by mollusks used as food (especially if eaten raw). Included here would be hepatitis, typhoid fever, paralytic shellfish poisoning, insecticide poisoning, and heavy metal poisoning.

The dominant role played by predation and disease in molluscan populations is slowly being elucidated. A new element, introduced by developing

cultural practices for certain commercial species, concerns the control of these and other environmental factors—reducing or eliminating their impact on molluscan populations.

POLLUTION AND COMMERCIAL MARINE MOLLUSKS

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Pollution is a word very much in the limelight today. Ketchum (1967) defines pollution as "any substance added to the environment . . . which has a measurable and generally detrimental effect upon the environment." This effect can take many forms including excessive nutrients, depressed oxygen levels, increased particulate matter, chemical and biological inhibitors, poisons, excessive heat, radioactive wastes, or, in the marine environment, too much freshwater. Mollusks which are used commercially can be concentrators of pollution; they can become contaminated with human disease organisms and unacceptable flavors. Pollution affects commercial mollusks, therefore, in two ways: by so altering the environment that mollusks cannot survive, and by so contaminating the mollusks that they are not suitable for human consumption. Among the many gradations that occur between extremes of toxicity, it should be noted that pollutants are often especially lethal to larval forms, and adult mollusks may survive conditions that are toxic for their larvae.

Commercial mollusks are particularly susceptible to pollution because they are found in areas where pollution frequently occurs and because they are essentially sedentary animals and cannot leave the polluted area. Since estuaries and continental shelves where mollusks are fished are bordered by human activity, the sources of pollution are close to hand and the pollutants are more concentrated than in open waters of the ocean. Sources of pollution range from freshwater to pesticides, and include domestic sewage, liquid waste products from agriculture and animal husbandry, heavy metals, petrochemical wastes, pulp mill wastes, radioactive wastes, detergents, and excessive heating of water. Freshwater runoffs differ from the other sources in that they are rarely attributed to human activity; but the sudden and extreme change in the chemical nature of the environment that they cause has been responsible for serious mortalities in oysters (Engle, 1946). The silting accompanying a freshwater runoff can clog the gills of oysters so that they smother, or may bury them completely (Waugh, 1953). Domestic sewage not only is a main source of contamination but also adds nutrient materials which cause oxygen depletion and encourage the development of microorganisms toxic to mollusks. Similar adverse effects come from agricultural practices—the instance of pollution by manure from the duck farms in Moriches Bay, Long Island is well-documented (Redfield, 1952) and farm fertilizers washed down by heavy rains have been suspected of contribution to the over-enrichment of estuarine waters.

Another industrial by-product, liquor from pulp mill operations, causes physiological damage to the filtering and feeding mechanisms of oysters (Hopkins, Galtsoff, and McMillin, 1931). Radioactive wastes are not, at present, much of a problem, principally because disposal has been so carefully monitored. It should not be forgotten, however, that the ability of commercial mollusks to accumulate trace elements would make them particularly likely to take in these radioactive wastes and so become contaminated.

Mollusks have the ability to concentrate trace substances many times greater than the levels present in their environment, and both heavy metals and pesticides are accumulated in this manner. This accumulation can upset the physiological processes of the mollusks—heavy metals may act as inhibitors to enzyme action and pesticides have been shown to inhibit shell movements of oysters and so curtail growth (Butler, 1966)— and it also makes them unsuitable as food. Shellfish can purge themselves of these substances if the source of pollution is removed and generally can recover if the damage has not been too great. Shellfish have been found to vary in their response to heavy metals. For example, copper has been found to be most toxic to the soft-shell clam and the edible mussel, zinc and cadmium accumulate most rapidly in the soft-shell clam, and the oyster is most likely to pick up lead. A mussel in Japanese waters was one of the principal carriers of mercury which, when ingested by humans caused the notorious "Minamata" disease.

The continued presence of petroleum oils in shellfish waters creates adverse conditions because the toxic substances released from oil interfere with the feeding mechanism of oysters and affect the growth of some of their natural food (Galtsoff, Prytherch, Smith, and Koehring, 1935). The detergents which have been used to clean up oil spillages have a much more drastic and immediate effect, however, and limpets that had been observed grazing on rocks covered with weathered oil were killed by the detergents used to remove the oil (Smith, 1968). Detergents were also toxic to topshells, winkles, mussels, and many larval mollusks. Shellfish harvested from oil-contaminated waters have a bad taste and are not acceptable for human consumption.

Thermal pollution is, perhaps, the one type of pollution which, if properly controlled, particularly during the cooler seasons, might be turned to advantage for commercial mollusks through the development of aquaculture. Nevertheless, any sudden and extreme heating could be dangerous for larvae and make the environment generally unsuitable through oxygen depletion.

The effect of pollution in molluscan populations has been most thoroughly studied in oysters, but, within the limits set by species differences, it would seem that all commercial mollusks have been affected by the pollutants mentioned. Nevertheless, instances have been rare when the pollution was so severe that an entire population was dangerously affected. More common are the situations where commercial mollusks have been implicated as carriers of human disease, resulting in adverse publicity for the entire shellfish industry.

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SYMPOSIUM ON COMMERCIAL MARINE MOLLUSKS SUMMARY

Arthur S. Merrill

United States commercial marine fisheries operate in waters of brackish to oceanic salinities. The fisheries can be separated in to two categories, those for coastal and inshore species and those for oceanic species. Coastal and inshore fisheries brought in 90 million pounds of meats in 1967, compared to 80 million pounds of meats from the oceanic fisheries. One of the inshore fisheries, that for oysters, accounted for 60 million pounds of meats in 1967 and, in addition, was the most valuable of all our mollusk fisheries. The largest oceanic fishery was for surf clams, but hard clams and scallops exceeded the surf clam in value although producing only one-third and one-fourth the volume of the surf clam fishery (see Table 1).

The inshore oyster fishery is harvested in a number of ways, from the traditional and technologically backward hand tonging and sail dredging, characteristic of the Chesapeake Bay area, to the more advanced methods of culture followed on Long Island and on the west coast. Much interest has been shown in modernizing oyster harvest methods, with an eye to increased efficiency in the fishery.

Inshore and coastal fisheries exist for hard and soft clams, *Rangia,* and razor clams. The fishery for the Pacific coast razor clam (*Siliqua*) is at present much larger than that for the east coast razor clam (*Ensis*) but there is a possibility of developing both a commercial and a sport fishery for *Ensis.* Many Pacific coast clam fisheries are now almost exclusively sport fisheries. The major Atlantic inshore clam fisheries, those for hard and soft-shell clams, show considerable variety in the technology employed; from primitive handraking and digging for the hard and soft clams to the mechanized dredges used in harvesting hard clams in Long Island Sound and the soft clams in Chesapeake Bay. The use of the escalator dredge has been a major factor in the remarkable growth of the soft-shell clam industry in recent years.

Table 1

U. S. MOLLUSCAN SHELLFISH CATCH—1967

Arranged by Region* (Thousands of Pounds and Thousands of Dollars)

Species	New England	Middle Atlantic	Chesa-peake	South Atlantic		Pacific	Total Catch	Total Value
Oyster								
Eastern (*Crassostrea virginica*)	323	1,190	25,798	3,160	21,747	13	52,231	$29,106
Pacific (*Crassostrea gigas*)	–	–	–	–	–	7,682	7,682	2,993
Western (*Ostrea lurida*)	–	–	–	–	–	44	44	140
Clam								
Hard (*Mercenaria mercenaria*)	2,899	10,243	2,156	234	354	296	16,182	11,981
Ocean Quahog (*Arctica islandica*)	45	–	–	–	–	–	45	6
Rangia (*Rangia cuneata*)	–	–	–	86	–	–	86	27
Razor (*Siliqua patula, Ensis directus*)	5	16	–	–	–	283	304	180
Soft (*Mya arenaria*)	4,207	373	5,243	–	–	–	9,823	3,936
Surf (*Spisula solidissima*)	16	43,889	1,149	–	–	–	45,054	4,352
Scallop								
Bay (*Argopecten irradians*)	455	248	–	387	7	–	1,097	1,053
Calico (*Argopecten gibbus*)	–	–	–	1,410	–	–	1,410	317
Sea (*Placopecten magellanicus*)	7,025	1,585	1,632	–	–	–	10,243	7,767
Periwinkle (*Littorina* sp.)	54	–	–	–	–	–	54	14
Squid (*Loligo* spp.)	1,819	1,393	584	42	48	19,606	23,492	663
Octopus (*Octopus* spp.)	–	–	–	2	–	49	51	10
Conch (*Busycon* spp.)	170	215	412	12	3	–	812	134
Abalone (*Haliotis* spp.)	–	–	–	–	–	888	888	865
Mussel, Sea (*Mytilus edulis*)	775	28	–	–	–	–	803	101
TOTALS	17,783	59,180	36,974	5,333	22,159	28,861	170,301	$63,645

* Source: Bureau of Commercial Fisheries Office of Statistical Services

An example of a coastal fishery which is at present underexploited, but with great potential, is found in the fishery for the blue or edible mussel. European methods of culture and management of this shellfish could be followed with profit in the New England area. Other New England coastal fisheries, such as those for the bay scallop and the periwinkle, may be amenable to further exploitation.

Fisheries for gastropods, such as the small periwinkle fishery off Maine, are of less importance than those for the bivalves, but the abalone fishery of the west coast is of some significance, and offshore fisheries for conchs are considered an underutilized but growing industry. Most of these fisheries brought in less than a thousand pounds of meats in 1967, but the abalone realized four to five times as much. Among the cephalopods, squid and octopus are fished in both Atlantic and Pacific waters, with greater abundance in the Pacific.

Surf clams and sea scallops are the outstanding shellfish caught in ocean waters off the United States. Both these industries grew rapidly in the 1940's and have flourished impressively since then. The calico scallop fishery is a very recent addition and is still in the exploratory stage as is the fishery for the sunray venus clam. Surf clam and sea scallop biology are quite well understood, but much is yet to be learned about the extent of the resources and the population dynamics of the other species.

Pollution of the coastal environment and molluscan habitat is a longstanding problem that constantly constricts the available area for commercial mollusk production. In recent years, pollution has removed vast areas of commercial shellfish from utilization for human food, largely through more critical assessment of domestic pollution by Government agencies and more stringent requirements for food purity, but also through real increases of industrial pollutants. Closely related to the pollution problem are those of predation and disease causing extensive mortalities in shellfish populations. Some shellfish diseases are critical in the area of public health, but most are restricted to the invertebrate populations. Finally, we must realize that molluscan resources are not inexhaustible and that some populations are near or at the point of being overfished. Good management and assessment techniques are required to prevent overexploitation.

To sum up, the United States enjoys a large and varied fishery for commercial mollusks, both inshore and offshore. In a few cases, the fisheries are well managed; in others, they are underutilized because of primitive methods of fishing, because of lack of information about the extent of the shellfish resource, or because the market value has not yet been developed. Disease and predation have always been factors that have limited the size of the shellfish resources. Now, however, a third factor has come in—pollution—and this may turn out to be the most serious problem that the shellfisheries have to face. There is no doubt that many of these problems can be resolved, and the commercial mollusks of the United States will continue to play an important role in our fisheries economy.

HOW MANY SPECIES OF MOLLUSKS ARE THERE?

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In the 10th edition of the Systema Naturae (1758) Linnaeus described over 600 species of mollusks. Since that time the total number of described species has increased enormously. Throughout the nineteenth century and during the earlier decades of the twentieth, great strides were made in *alpha*-taxonomy and several individual authorities named several thousand mollusks each. Frequently there were efforts to assess the total numerical diversity of the Phylum and most recently two authorities independently arrived at a figure near 107,000. However, in the literature there is wide divergence in estimates; totals range from about 40,000 to almost 130,000.

By employing several different approaches, I attempted to arrive at a more accurate and critical count. Malacological literature is extensive and reflects the diversity of the Phylum. To assess this diversity, I analyzed the faunal studies, monographic reviews, nomenclatorial handbooks and checklists of nomina.

Faunal lists provide some clue to the numerical diversity of mollusks of continental and insular land masses, fresh-water lakes and rivers, and ocean regions and basins. Systematic revisions offer the best assessment of the number of names given to a particular taxon and the critical taxonomic reference works on genera, as for example, Wenz and Zilch in the *Handbuch der Paläozoologie*, also provide evidence for consideration. Finally, lists of named species of a genus or family may be used in conjunction with what I have termed the synonymy ratio (SR). In complete monographic works, it was noticed that many species had been over-named. The SR is simply the number of available nomina for the number of actual species. This often averages 4/1 to 5/1, which means that in an overall analysis, a single species may have on the average four or five names. (The most over-named of all molluscan species appears to be the Swan Mussel, *Anodonta cygnea* L., of Europe with over 550 names!!) Thus, when confronted with a list which indicates that there were 1000 available nomina, I could use a SR of 4/1 and estimate 250 species in the group. Additionally many colleagues provided estimates on groups they are currently revising.

If subtotals are tallied for geographic regions, the figure arrived at falls well below 50,000. When the prosobranchs and pulmonates are analyzed, they indeed prove to be numerous but not enough to equal earlier estimates. Also in a family by family analysis of bivalves, my final figure is far short of recent estimates. Thus several sources of evidence show that many previous estimates are clearly erroneous. I found that there are about 35,000 species of mollusks known, and allowing for error and guessing at the number of species yet to be discovered, I estimate that there are nearly 47,000 species.

The following are my final approximations: Aplacophora, 250; Polyplacophora, 600; Scaphopoda, 350; Cephalopoda, 600; Monoplacophora, 10; Bivalvia, 7,500; Gastropoda, 37,500 (Basommatophora, 1000; Stylommatophora, 15,000; Prosobranchia, 20,000; Opisthobranchia, 1500).

A FLORIDA *GASTROPTERON*

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Abstract

The genus *Gastropteron* Kosse 1813 contained only five species up to 1964. By 1965, Tokioka and Baba had added five more from Japan; Marcus and Marcus named a new subspecies in 1966. Of these, the only species reported in the Western Atlantic was *G. rubrum* Rafinesque 1814, found in Alligator Harbor near Tallahassee, Florida, collected by Dr. Harold J. Humm.

On April 6, 1970, in the shallow water of Boca Ciega Bay, part of the Tampa Bay complex on Florida's Gulf Coast near St. Petersburg, a colony of *Gastropteron* were found on soft, sandy mud among patches of shoal grass (*Diplanthera wrightii* [Ascherson] Ascherson). These proved to differ in many significant characters from the known species.

Many specimens were maintained in an aquarium for over one month. This paper reports some observations on the ecology, general and reproductive behavior of the Boca Ciega Bay *Gastropteron*. A complete and detailed report is planned when the species is named.

MONTACUTA FLORIDANA DALL AND *ALIGENA ELEVATA* (STIMPSON) AS CLOSELY RELATED SPECIES

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Abstract

The family Montacutidae has long been characterized by the possession of only a single (inner) demibranch. *Montacuta floridana* Dall and *Aligena elevata* Stimpson are therefore of special interest as montacutids in that, in addition to the well-developed, inner demibranch, they both possess a poorly developed, outer demibranch in the form of a few, short, upward directed gill filaments. The two species are similar also in having tissue of the visceral mass (gonad and digestive gland) protrude laterally in the form of ridges (usually three), oriented at the same angle as the overlying gill filaments of the inner demibranch. Additional similarities involve size of the labial palps (quite small relative to gills), hinge structure (teeth and ligaments), general form and sculpture of shell, and appearance of the mantle (middle lobe with short, tentacle-like papillae along free edge). The two species also appear to have a similar mode of existence, both being attached to the lower ends of vertically oriented tubes of annelid worms . . . *M. floridana* with *Onuphis magna* (Onuphidae) and *A. elevata* with *Clymenella torquata* (Maldanidae). Thus in general appearance and in several significant details,

the two species are very similar. Indeed, with regard to the above mentioned anatomical features, *A. elevata* may be considered a miniaturized version of *M. floridana*. It is concluded that the two species should be placed in the same genus.

FERTILIZATION IN *DISCUS*

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In *Discus cronkhitei* sperm cells received from another individual during copulation are channeled to the seminal receptacle for temporary storage. A part of this sperm mass moves back down the duct of the receptacle, then up through the spermoviduct to the talon; the remainder of the mass disintegrates in the receptacle. The epithelium of the receptacle varies from cuboidal to tall columnar, depending on the functional state. Two distal, spherical chambers of the talon serve for temporary storage of sperm cells received from another individual. Mature oocytes move by way of the little hermaphroditic duct to the principal chamber of the talon, where sperm penetration occurs. The fertilized ovum moves to a distal pouch of the spermoviduct, where fluid from the albumen gland also accumulates. The pouch secretes the egg membrane, to which a rigid, calcareous covering is added. Eggs are deposited singly and at random on the surface of the substrate. This sequence of events was deduced from the study of intact, dissected, and serially sectioned specimens collected in the Sandhills region of central Nebraska.

In the closely related endodontid, *Anguispira alternata*, the basic plan of the reproductive tract is similar to that of *Discus cronkhitei*. Conspicuous differences exhibited by *Anguispira* include: 1) presence of a strongly ciliated strip in the epithelium of the little hermaphroditic duct; this strip propels the oocytes to the talon; 2) a more complex talon, which includes a highly expandable, cylindrical chamber in which fertilization occurs, and two or three cylindrical chambers for the temporary storage of sperm cells received from another individual; such sperm cells are oriented, with the heads embedded in the epithelium of the chambers; 3) presence of a pilaster in the penis; 4) presence of numerous calcareous tetrahedrons, which are produced in crypts in the epithelium of the pilaster of the penis and which are transferred with the seminal fluid; and, 5) deposition of eggs in clutches of twenty to thirty in burrows in the substrate.

THE RENOPERICARDIAL APERTURE IN *DISCUS*

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In *Discus cronkhitei* the renopericardial aperture opens to the pericardial cavity in the region of the ventricle. In 5.0–5.5 mm specimens the aperture averages 28 micra in diameter. Its epithelium is strongly ciliated. The aper-

ture leads to a slender, curved canal which is 100–120 micra in length and averages 25 micra in diameter. The epithelium of the canal is ciliated. The termination of the canal invariably is adjacent to the epithelial covering of the kidney. A single layer of epithelium separates the termination of the canal from the mantle cavity. The significance of this relationship is not understood. The termination of the canal does not exhibit an increase in diameter. The slit-like communication with the kidney spaces is tightly folded.

In *Anguispira alternata* the renopericardial aperture also opens to the pericardial cavity in the region of the ventricle. In specimens 15–18 mm in shell diameter the aperture averages 68 micra in diameter and the epithelium is strongly ciliated. The aperture leads to a canal which is curved and which has deep, radial folds. The total length of the canal averages 750 micra. The epithelium is strongly ciliated. Most of the canal is located deep within the kidney tissue, but the terminus of the canal turns back toward the surface of the kidney. The slit-like communications of the radial folds with the kidney spaces are tightly folded.

In *Triodopsis* sp. the renopericardial aperture opens to the pericardial cavity in the region between the atrium and the ventricle. In 22–25 mm specimens the funnel-shaped aperture measures about 340 micra in maximum diameter. Throughout its length the walls of the canal are highly folded. The folding begins at the aperture, in contrast with the unfolded nature of the wall in the aperture region in the two species cited above. The total length of the canal is about 1,200 micra. The canal is located deep within the kidney tissue, curving toward the surface of the kidney. The communications of the radial folds with the kidney spaces are tightly folded, as in the two species cited above.

LABORATORY METHOD FOR GROWING FRESHWATER SPONGES, UNIONID MUSSELS, AND SPHAERIID CLAMS

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ABSTRACT

The scientific literature shows that considerable effort has been devoted towards growing freshwater sponges and mussels under laboratory conditions with limited success. Granular feed for trout fry served as a good growth medium in the laboratory with both running carbon filtered city water and water pumped directly out of Lake Superior. Some sponges increased several fold in size. The sponges also lost their gemmules and increased their number of narrow extensions probably because the temperature and flow velocity were different at the collection site. Two year old unionid mussels consistently grew 20% in length in three months. Sphaeriid clams grew at the same rate.

A LOCAL CASE OF INTRA-POPULATION VARIATION IN *LYMNAEA EMARGINATA* (SAY)

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North American malacologists have long been influenced by the precise work of our early conchologists, as exemplified by Frank Collins Baker. He felt ". . . that mass variations [in morphs] of the creeks, small rivers, large rivers, etc., should be distinguished . . . and given definite names . . ." (Baker, 1928). Although Baker recognized these morphs as "ecological varieties" many were given species names and most subsequent workers have considered them as species. The supposition that isolated populations with any recognizable differences in shell shape represent distinct species, and the naming of these, has almost unknowingly reinforced the assumption that there is little external variation within species of fresh-water mollusks.

The opposite opinion is held by Bengt Hubendick (1951, 1962) who feels that fresh-water molluscan species are usually widespread and quite variable in morphology, but relatively few in number. These ideas are based on the ephemeral characteristics of the fresh-water environment. Although during any one period there are many isolated populations of mollusks, he feels that because of the short geological life of lakes and streams, these populations rarely are isolated for enough time to become fully speciated. His 1951 monograph on the Lymnaeidae, in which he lumps over 50 named North American gastropods into about 10 distinct species, has not been favorably accepted by the majority of North American malacologists.

Neither viewpoint can be reconciled by the heated discussion that occurs between the proponents of each belief. In the absence of breeding experiments and cytological data it becomes practically impossible to prove which is the more nearly correct hypothesis. I have, however, discovered a population of *Lymnaea* (*Stagnicola*) *emarginata* (Say) that exhibits pronounced variation in shell morphology from one part of its range to another. These differences are not random in nature but form a clinal pattern from one extreme to another. I believe that the intra-population variation shown in this case lends strong support to Hubendick's point of view.

The population occurs in Skaneateles Lake, Onondaga County, New York. Skaneateles is a typical Finger Lake with long straight shorelines dropping rapidly into deep waters (Fig. 1D). It is approximately 14 miles long with a maximum depth of 90.5 meters (297 ft) (Birge and Juday, 1914). Collecting took place along ten transects that were made from more or less equidistantly spaced locations along the east shore of the Lake. Equipped with an aqualung, underwater notebook, hand sieve, and collecting bags, I extended each transect by swimming from the shoreline to the maximum depth at which living mollusks were encountered. Many additional dives were later made between the quantitative collection areas to verify interpolation of the species distribution pattern.

The distribution of *L. emarginata* in the Lake is shown in both horizontal (Fig. 1D) and vertical (Fig. 1E) planes. Figure 1D shows species distribution in

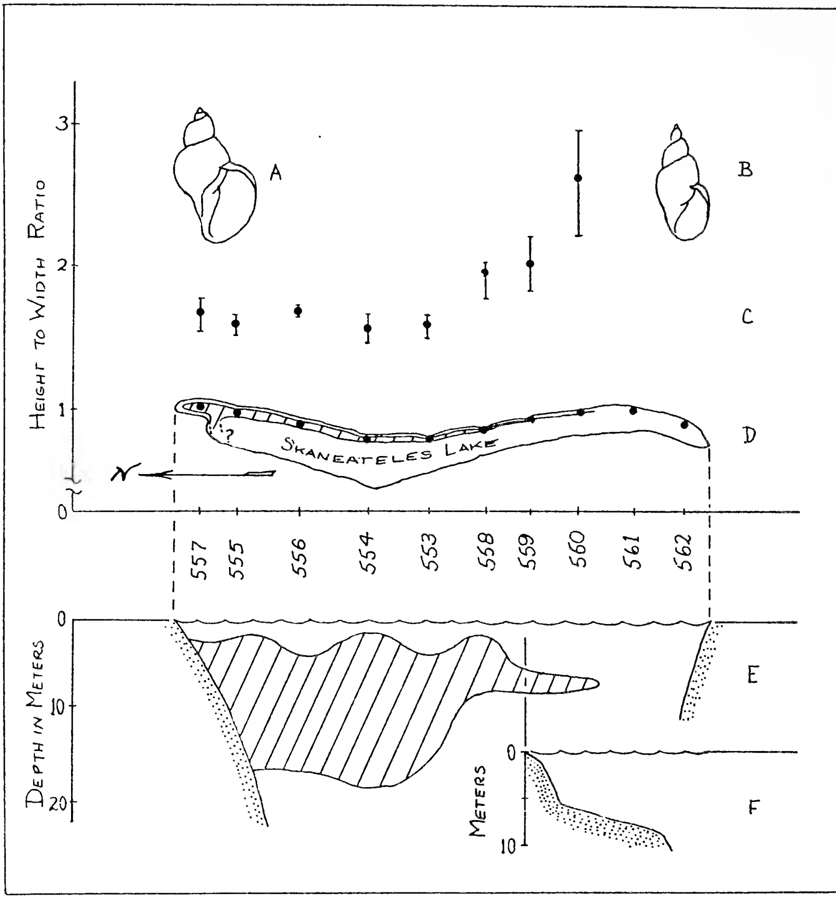

Figure 1. A. Specimen of *L. emarginata* from collection area 557 that resembles *Stagnicola emarginata wisconsinensis* (F. C. Baker).
B. Specimen of *L. emarginata* from collection area 560 that resembles *Lymnaea montana* Elrod.
C. Height to width ratios of *L. emarginata* at various stations along the east shore of Skaneateles Lake.
D. Map of Skaneateles Lake showing horizontal distribution of *L. emarginata*.
E. Vertical distribution of *L. emarginata* in Skaneateles Lake.
F. Angle of repose of substrate at Station 559.

the usual way and illustrates the extremely long and narrow pattern typical of mollusks living in the central New York Finger Lakes. Figure 1E is a longitudinal diagram of the Lake showing the depth distribution of *L. emarginata* as the bottom slopes downward from the east shore to the depths. This sloping bottom is necessarily represented on a vertical plane; and differences in gradient are not shown. The vertical distribution of the species can be

explained by variations in the angle of repose of the substrate (Fig. 1F). *Lymnaea emarginata* occurs only on the gently sloping bottoms.

Height to width ratios of individual specimens were determined by measuring the length of their shells from the tips of the spires to the lower lips of the apertures, and dividing the results by the maximum widths of shells occurring at 90° to the first measurement. Specimens collected at the northern end of the range, where the greatest area of optimal habitat occurs (transects 557, 555, 556, 554, 553), exhibit H : W ratios averaging slightly above 1.5. In the southern portion of the range, where the available habitat is very limited, individuals reach a H : W ratio of 2.9, the mean being 2.53 (Fig. 1C). The illustrations of snails in Fig. 1 typify the morphology of individuals at each end of the range. Specimens from the north approximate Baker's *Stagnicola emarginata wisconsinensis* (F. C. Baker) from Little Arbor Vitae Lake in Wisconsin (Baker, 1928) (Fig. 1A), while those from the south resemble *Lymnaea montana* Elrod from the Mission Mountains in Montana (Hubendick, 1951) (Fig. 1B). Specimens found in collection areas 558 and 559 are intergrades between the two extremes.

The clinal variation in this population of gastropods may be the result of moderate gene flow from one end of the population to the other, the reflection of varying environmental stresses on the phenotypes at either end of the range, or both. What is important for this discussion is that as much non-random variation occurs in this one population as is shown in several named "species" across the continent. The association of these morphs in one population supports my belief that intraspecific variation is greater in fresh-water gastropods than that indicated by our current taxonomic usage.

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AMPHIGYRA, MINIPLANORBS AND MICROSCULPTURE IN PLANORBIDAE SYSTEMATICS[1]

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Initial observations on microsculpture in these taxa were presented in a lecture at the 1963 A.M.U. meetings. Some photographs and technique data

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have been published elsewhere (Walter, 1968, Malacological Review, *1*, pp. 80–87, figs. 96–99). A survey of basommatophoran microsculpture showed that, almost exclusively, the Planorbidae have diverse and complex types of sculpture, whose sequential aspects in ontogenetic phases on the shell may have taxonomic and phylogenetic import. Here I can touch on little more than spiral components of the embryonic sculpture, which are of foremost significance, and their correlation with some other morphological features of mini-planorbs.

To render shells microscopically clean inside and outside, as study by transmitted light required, they were immersed in "household bleach"—about 5% sodium hypochloride—that dissolved any animal remains along with the periostracum, which commonly was infiltrated with opaque environmental matter. A large number of shells that have relatively few and capacious whorls and are not too well-infiltrated may be so cleaned in a few minutes in one vial or jar. Other shells may present difficulties, and the treatment may leave behind patches of infiltrated matter that have to be removed with a fine needle or brush. Shells were studied while temporarily mounted in a thin agar gel, thinly covered with water, in dishes small enough to fit on the stage of a compound microscope. Often using only a needle, extensive series of small shells could be arranged in any desired order in one dish, and each specimen could be quickly maneuvered into any desired exact orientation. Serious comparative microsculpture studies were forestalled until this methodology was developed through lengthy experimentation.

The most complex type of sculpture occurs in three forms of *Taphius andecolus* (including *Platytaphius*) from Lake Titicaca (Fig. 2a), *Taphius pronus*, "*Promenetus*" *umbilicatellus* and *Physastra* spp. The protoconch is densely, intricately and finely wrinkled, showing in some form nearly all types of sculptural elements occurring in Planorbidae; subpunctate, it shows

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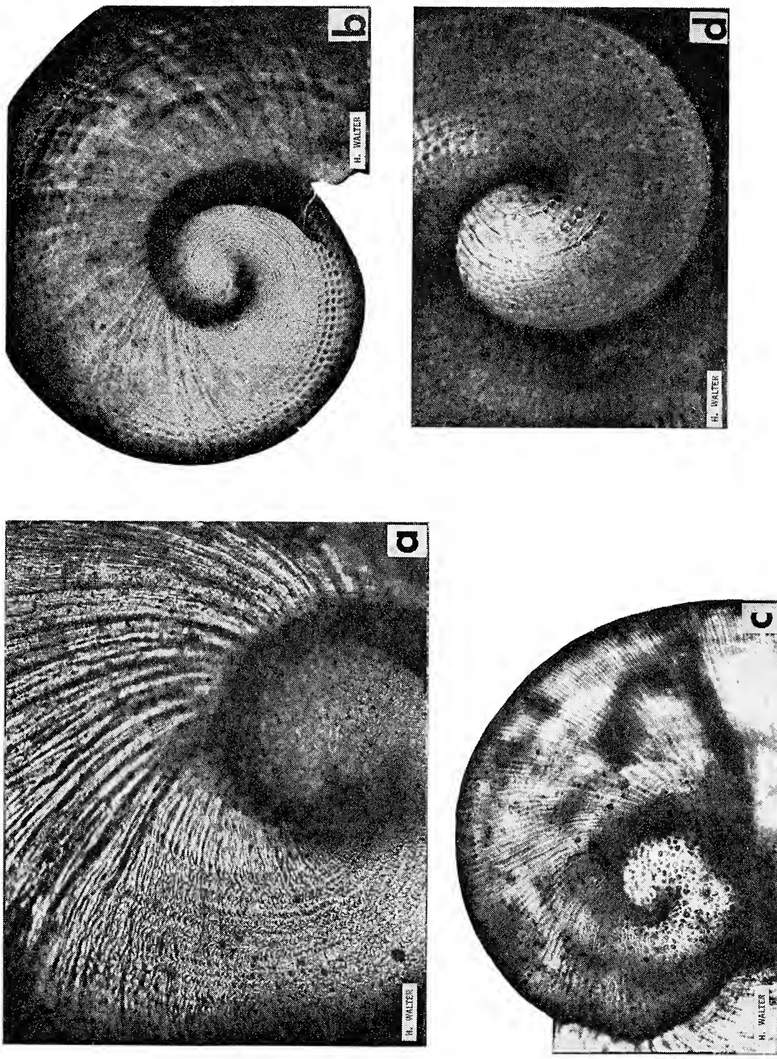
Plate 2. Early whorls of Planorbidae seen by transmitted light at various magnifications.

Figure a. *Taphius andecolus* from Lake Titicaca, typical form. A slight change in the lighting can make the subpunctate condition, obscure here, evident. Collected by Mary Heil.

Figure b. A *Drepanotrema* from Texas of the "*Antillorbis*" type, evidently representing a subspecies of "*Gyraulus*" *circumlineatus* Shuttleworth, chiefly differentiated on its prominent peripheral nuclear punctation. The postnuclear whorls of this adult shell largely were broken away to expose the periphery of the first whorl. The ultramicrocords are retouched. UMMZ 87541.

Figure c. *Amphigyra alabamensis* from Duncan's Riffle, Coosa River, of the "*Neoplanorbis carinatus*" form. Traces of postneanic microcords, here somewhat out of focus, may be seen. UMMZ 102677.

Figure d. *Segmentina nitida* from France. Umbilical side of protoconch, showing nodulous microcords coarser than in *Gyraulus*. UMMZ 89964.



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numerous spiral rows of fine crowded depressions. Among *Helisoma, Carinifex* and *Parapholyx,* the sculpture is very similar, to simplified (as in *Indoplanorbis*?) to seemingly obsolescent. The non-punctate protoconch is essentially sculptureless in "*Planorbula*" *campestris* and *Biomphalaria* (including Neotropical "*Australorbis*" and "*Tropicorbis*"). Weak embryonic punctation, the punctae being shallow and variably crowded within moderately well-spaced spiral rows, was seen in "*Promenetus*" *exacuous,* "*Menetus* s. s." from Washington and *Planorbula armigera.* *Bulinus* spp., *Planorbarius corneus* and the Algerian *Planorbarius dufouri* have well-spaced spiral rows of sharply defined pit-punctae.

In *Drepanotrema* of the *kermatoides* group and in *Gyraulus*-like "*Antillorbis*" from Texas and Yucatan (possibly *circumlineatus* Shuttleworth), the protoconch is sculptured as in *Bulinus* except in a sharply differentiated adaxial zone that bears many extremely delicate but sharply defined spiral ultramicrocords (Fig. 2b). *Drepanotrema* of the *anatinum* and *limayanum* groups have at least similar prominent punctation as does Panamanian "*Promenetus*" *minutus* Taylor. In Puerto Rican "*circumlineatus,*" however, the punctation is decidedly finer and grades to ultrapunctation in the adaxial region. "*Gyraulus*" *carus* (Pilsbry) from Texas has ultramicrocords over the whole protoconch, which otherwise seems uniquely smooth.

The non-punctate protoconch of *Planorbis planorbis* and various *Gyraulus* from different continents have a few sharply defined microcords (about 9 in apical and umbilical views) on a decided axial sculpture. Apparently little different are "*Spirorbis,*" "*Armiger*" and West African "*Anisus*" *coretus.* The European *Segmentina nitida* has much broader nodulous cording semimergent with axial elements that forms a peculiarly smoothish sculptural type that may tend towards obsolescence in Asian snails of the *Segmentina* tribe (Fig. 2d). In West African *Segmentorbis* (*Acutorbis*) the cording is much as in *Gyraulus* and even finer. *Camptoceras hirasei* has a simple embryonic decussate pattern of impressed lines, differing therein from *Physastra,* contrary to an earlier report of mine.

A protoconchal punctate ornamentation, differing markedly from all others seen, is conspicuous by transmitted light in *Micromenetus* (considered a full genus here) from Ohio, Illinois and the Coosa River of Alabama. Identical ornamentation exists in all nominate taxa of the "ancylid Neoplanorbinae" and may be pseudosculpture. The punctae, markedly irregular in size and disposition, are not spirally aligned, and are largely coalescent within clumps. They may be "bubbles" in the shell substance. Another species of *Micromenetus* from southern Illinois that resembles "*Promenetus exacuous*" has finer punctation.

Nearly all known *Amphigyra* and "*Neoplanorbis*" populations, including representatives of all five "Neoplanorbinae species" were studied on the basis of collections made in the Coosa River, Alabama prior to 1910 (Fig. 2c). The few large series, from Duncan's Riffle, Chilton Co. contained specimens showing every possible gradation between crepidulaform *Amphigyra* and "*Neoplanorbis carinatus*" in respect to shell form, whorl coiling, apertural flaring, carination, columellar shelf development, etc. All series, including paratypic sets, showed variation toward the crepidulaform condition. No series contained more than a few examples that fit any of the typal diagnoses.

Accordingly, "Neoplanorbinae" is viewed as merely one species, *Amphigyra alabamensis*. Its forms share a common neanic (crowded microriblets) and postneanic (microcords) sculpture, slightly varying in relation to variation in coiling, flaring, and (evidently) to population genetic trends. The neanic phase is prolonged in more coiled variants (a phenomenon also detectable among *Micromenetus*, which have comparable sculpture), and is almost "squeezed out" in extremely flared specimens.

Radulae of *Amphigyra* and *Micromenetus*, despite some obvious differences, are identical in numerous details respecting tooth bases and crowns, and the shape, number and disposition of cusps and cusplets. They show significant similarities to African *Pettanyclus*, among other ancylids. Seemingly, complete *Amphigyra* transverse tooth series were inherited in *Micromenetus*, then crowded against the rhachidian row, so as to squeeze out many teeth of intermediate form and leave space marginally for "hypermarginals," which arise as a radically "new" tooth type, next to a broad marginal quite like the last in *Amphigyra*. The "new" type corresponds to the narrow marginal type common in Planorbidae, practically identical in all respects to that I recently figured for *Bulinus* (op. cit.). The jaw in *Amphigyra* and *Micromenetus* is of the tripartite type common in Planorbidae.

In the Ohio *Micromenetus*, taken from rivers at Dayton, the columellar muscle is shortened and expanded over the right side of the lung, where a muscle mass diverging from it disrupts the integument to form an "adductor muscle scar" comparable to that of a limpet. In other structures, such as the pneumostomal appendage(s), the snail seems to be ordinarily planorbid, except for a peculiarly simple small anterior prostate. It has no apparent vaginal specializations. The penial complex shows features of both Neotropical *Helisoma wyldi* and *Parapholyx effusa* as they are depicted in the literature, with the holdfast organ much as in the latter, the long external duct having a balloon-like expansion, and the penial pore being markedly subterminal. The animal is blackish, with large eyes and very red blood.

I view *Amphigyra* and *Micromenetus* as constituting a tribe of Planorbidae linked to the Ancylidae. Present evidence may require placing "*Menetus* s.s." species, "*Promenetus*" *exacuous*, and "*P.*" *umbilicatellus* under *Planorbula*. At least the two "*Promenetus*" have a campanulate vagina proper bearing a pair of calcareous claw-like structures. Numerous calcareous provaginal hooks were seen in *Chilina*. Comparable armature is otherwise lacking or unknown in Basommatophora. Similarity of the receptaculum seminalis (separate from the "bursa") in *Chilina*, *Latia*, and *Laevapex*, as well as of *Laevapex* and planorbid carrefours, bolster the view that the Ancylidae and Planorbidae may constitute a primitive single family.

INTRODUCTION TO SYMPOSIUM ON INTRODUCED MOLLUSKS

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The activities of both primitive man and modern commerce have resulted in both the extinction of many mollusks and the introduction of others into areas that are remote from their original habitat. While many of us tend to study the exotic or natural area species, introduced forms provide a laboratory of evolution and ecological interaction that in terms of speed and drama rarely can be matched by balanced, undisturbed faunas.

As part of the meeting dealt with the usefulness of mollusks as food for many, it was thought that a series of status reports on North American introductions would be a valuable landmark serving to alert both amateurs and professionals to the opportunities for study and the problems of data gathering concerning introductions. The following eight papers, together with the report on *Marisa* by Dr. Robins, cover most of the introduced groups on land and in fresh water. Unfortunately, it was not possible to survey marine introductions associated with oyster fisheries, nor was there a speaker available on the status of introduced Viviparidae and Bythinidae.

The symposium was organized by myself. Dr. Albert R. Mead graciously consented to chair the session in addition to presenting two of the talks. Through the courtesy of Dr. Lowell Getz, the symposium papers will be published in full in the Fall, 1971 issue of "The Biologist." Only program abstracts are reproduced here.

Because of the extraordinary interest it has for ecology minded public of today, Mrs. Sturgeon's account of the outbreak of the giant African snail *Achatina* in Florida is here presented in full.

ACHATINA FULICA BOWDICH INFESTATION IN NORTH MIAMI, FLORIDA

RITA STURGEON
South Miami, Florida

In 1938 *Achatina fulica* Bowdich was discovered in Hawaii. Repeated efforts at eradication there have failed.

Despite the vigilance by USDA Plant Quarantine officials, it has been feared that someday it would become established on the mainland. Abbott[1] (1950) predicted "It is my opinion . . . that the southern one third of Florida is the only suitable area for its survival for any length of time."

A small boy's curiosity and optimum conditions have resulted in the fulfillment of his prediction and a dangerous threat to Florida's economy.

In June 1966 three snails were brought by a young boy from Hawaii and released in North Miami. A combination of factors were instrumental in the

[1] R. Tucker Abbott, Dupont Chair of Malacology, Delaware Museum of Natural History

snail's survival: lush tropical foliage, an abundance of calcium carbonate (Dade County marl consists of 90% $CaCO_3$), lack of natural predators and an extremely mild winter. Average high for the 3 month period (December, January, February), was 77.5°; average low, 60.4°. During this period the temperature dropped below 50° on only 12 days. Low of 36° was recorded on February 26.

As the snails multiplied, they moved naturally in search of food. The spread was aided by its primary vector, man. In the words of the boy's grandmother, "Stevie was a hero to not only the children but also to their parents until now." The neighborhood children had found a new hobby—snail raising.

With favorable conditions continuing through the winter of 1968, the population increased to alarming proportions. What had been fun to the residents now became a nightmare. Shrubs were defoliated, annuals and vegetables could not be raised, and lawn mowers were damaged by striking snails resting in the grass. It was impossible to walk without crunching snails underfoot. Paint on the houses was marred and sheds were filled with excreta. Air conditioners were stopped up; foul odors from decaying snails permeated the air.

On September 12, 1969 the Miami Herald contacted the Dade County Agricultural agent regarding a reader's complaint about snails in a North Miami neighborhood. The county agent collected specimens and notified the Florida Department of Agriculture and Consumer Services, Division of Plant Industry. Dr. Fred Thompson[2] identified the snails as *Achatina fulica*, the Giant African Snail.

Within a week agricultural officials of the Division of Plant Industry and USDA Plant Protection Division determined that the infestation apparently covered a 40 square block area; 133 properties were found to be infested. Fearing that children may have taken the snails home, plans were underway for a property to property survey of the Gratigny school district. Residents were questioned as to place of employment, driving patterns, names of gardeners, methods of disposing of trash.

Despite warnings of danger by Doyle Conner, Commissioner of Agriculture, and the announcement of quarantine lines, the work was complicated by people swarming to the area over the weekend after the publicity broke. This caused concern, as many were known shell collectors. It was feared that people who raise and are familiar with the habits of our native *Liguus*, not realizing the biotic potential of this snail, would attempt to raise them.

A second infestation came to light on September 28 when a Division of Plant Industry plant specialist saw a specimen in the County Agent's office in Broward County. An employee of a pest control concern had carried some snails to Hollywood eight months previously; apparently some escaped. A delimiting survey of the area revealed six infested properties. No snails have been found for approximately four months; though treatment is continuing the infestation is considered eradicated.

A third infestation was discovered by a resident ½ mile due west of the original infested area. Six properties were found infested.

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[2] Fred Thompson, Assistant Curator of Mollusks, Florida State Museum

Initial application of 3.25% metaldehyde, 5% tri-calcium arsenate and 91.5% inert materials (formulated into pellets) was applied to the infestations on October 1 and 2. A 300 foot border was treated around the infested areas.

Weekly treatments were continued until November when a bi-weekly schedule was initiated. Since the spring rains of 1970, treatment is again on a weekly schedule.

Treatments are accomplished by means of hand labor using grass seeders to spread the pellets. Every precaution is being taken; pellets are removed from sidewalks, carports, around swimming pools by sweeping.

A check area of 22 properties was selected in the Dade County infestation to evaluate treatments. Weekly on the day before treatment, a count of live and dead snails is made on the 22 properties.

Along with the chemical control, snails are hand picked. By January 1970 the count of hand picked snails was approximately 15,000.

Over 400 leads have been checked out; brochures describing the snail and its habits have been distributed to school children; talks have been made in schools and before civic organizations to warn the populace of the dangers and problems faced by Florida agriculture.

Molluscicides for use in this infestation are being screened in Hawaii by Plant Protection Division personnel. Preliminary testing work by Dr. D. O. Wolfenbarger[3] in the infested area has shown that the material being used is as effective as any other molluscicide he tested.

Dumps, drains which empty into the Biscayne Canal, the environs of the canal were also surveyed. Hot spots, or areas of potential infestation sites which came to light during survey, will continue to be under surveillance.

Survey and efforts to eradicate the snail will continue. The snail count in the 22 property check area has decreased from a count of 828 dead snails and 117 live snails on October 14, the day before the third treatment, to a count of 20 active and 16 dead snails on July 6, 1970. A three week period when all live snails were being kept for examination produced only 40 live snails. On July 14 not a snail could be found.

The snail has not been found in locations other than those above mentioned. The feeling of the agencies is optimistic. The prognosis is guarded. Complete eradication will take the combined efforts of both agricultural agencies along with the cooperation of the citizens in not carrying the snail beyond its present boundaries.

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[3] D. O. Wolfenbarger, Entomologist, Institute of Food and Agricultural Sciences, University of Florida, Sub-tropical Experiment Station, Homestead, Florida

LITTORINA LITTOREA, NATIVE OR INTRODUCED? — A REVIEW

ARTHUR H. CLARKE
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ABSTRACT

Recent archaeological finds indicate that *Littorina littorea* is native to North America and not introduced. The cause of its sudden and conspicuous range expansion after 1850, however, remains unknown.

CORBICULA AND *DREISSENA* PARALLELS

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Abstract

The Oriental *Corbicula* has in three decades become widely dispersed in North American freshwater habitats from California to Florida. It parallels the Ponto-Caspian species of *Dreissena*. Unfortunately a language barrier prevents full use of Japanese literature on the *Corbicula* species aggregation.

INTRODUCED SUBULINIDS AND VERONICELLIDS

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Abstract

A review of the present status concerning introduction, spread, and potential economic impact of the many introduced species belonging to these families.

HELICID LAND MOLLUSKS INTRODUCED INTO NORTH AMERICA

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Abstract

Because some of the larger helicines are prized as culinary delicacies, several species have been purposefully or unwittingly introducd and established in many parts of the country. Both these and some of the less conspicuous species have demonstrated a capacity of becoming serious garden and horticultural pests under favorable conditions.

INTRODUCTION AND SPREAD OF THIARIDS IN THE UNITED STATES

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Abstract

Several species of the family Thiaridae have spread from Florida to Oregon since their first apparent introduction from the Orient to the United States in 1935. Although populations of these snails are geographically sporadic, members of this family present several biological problems to be considered.

INTRODUCED TERRESTRIAL SLUGS

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Urbana, Illinois
and
Lyle F. Chichester
Department of Biological Science, Central Connecticut State College
New Britain, Connecticut

Abstract

A review of the zoogeography and ecology of terrestrial slugs introduced into North America. Methods of their introduction and dispersal as well as association with man's activities are discussed.

STATUS OF *ACHATINA* AND *RUMINA* IN THE UNITED STATES

Albert R. Mead
University of Arizona

Abstract

Achatina fulica and *Rumina decollata* have much in common as persistent, hardy, adaptive, prolific pests of gardens and nurseries. *A. fulica* is destined to follow the example of *R. decollata*, which in recent years has moved across the country from Florida to Texas to California.

A TYPE OF NUDIBRANCHIA BIBLIOGRAPHY

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Many years ago, 1935 to be exact, I found that to work with the Nudibranchia I needed a good reference bibliography. I started one, dropped it for years and took it up again in 1963—with completely revised ideas about making it more useful. The present nudibranch bibliography is composed of four chief parts:

1. Authors' Catalogue (1554–1965) carrying the author's name, the title of his work and where it was published. There are about 2400 of these—each consecutively numbered.

2. Geographic Catalogue. This bears the name of countries, islands or island groups from which species have originally been described. There are latitude and longitude references, Miscellaneous, and Locality Not Recorded headings.

3. Genus and Species Catalogue. This carries the original name of the genus or species, the author, the bibliographic reference and other information that may be of use to the user. There are about 3400 of these.

4. Subject Catalog. This is composed of about 200 major and sub-subject headings with numbers referring to those for each of the authors' references, as a cross-reference.

Finally there is the abbreviation file which carries the bibliographic source abbreviations used in the authors' and geographic catalogues and a fully written out description for these, so that the reader can get the full reference should he need it. It is hoped that the bibliography will appear in print in the not distant future.

ANATOMICAL STUDIES IN THE FAMILIES UROCYCLIDAE AND HELICARIONIDAE: PULMONATA, STYLOMMATOPHORA

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Urocyclidae (Ethiopian Region) and Helicarionidae (Oriental Region) are two pulmonate families showing similar evolutionary trends towards the realization of a slug type with reduced shell. The marked superficial resemblance of species belonging to these families explains the confusion in classification. In fact, they show some striking similarities in anatomical characters that may involve close affinities. However, significant and constant differences in the specialized genitalia prove that they have diverged from an ancient common stem.

The progressive reduction of the shell and pallial cavity involves a new disposition of the kidney and the pulmonary surface. In urocyclids the posterior part of the kidney expands progressively and reflects ventrally into a broad transversal body, the pericard moves forward and the pulmonary veins invade the diaphragm. A similar trend in kidney reorganization in helicarionids has been described by Solem.

The genital tract of the more specialized species shows identical organs. The epiphallus is provided with a peculiar flagellum consisting of a hollow tube containing an axial, cylindrical process, and a caecum. This ephiphallian complex is provided with a ciliated columnar epithelium on its inner surface. This plays a role in forming the horny spermatophore. In the Urocyclidae the flagellum changes into a reduced epiphallic bursa: an ovoid, thin-walled, simple sac covered on the inside with a very flattened epithelium.

The penis is covered by a tubular, muscular penis-sheath. In all urocyclids and also the most specialized helicarionids, the apex of this sheath is fused to the wall of the penis and sometimes envelops the caecum too.

Both families share a strong tendency towards the acquisition of specialized genital organs, but their marked similarity is purely superficial and may have come into being through convergent evolution.

The Urocyclidae have two different types of stimulators which never exist simultaneously:

1. The sarcobelum consists of a thick, muscular tube with a narrow axial lumen, which is covered by a simple epithelium, while the muscular fibers are spirally arranged. This organ is devoid of important glandular equipment,

but in the most specialized forms (*Urocyclus*) it is capable of secreting one or more calcareous darts. The origin of this organ is clearly demonstrated in the genus *Zonitarion*. The more primitive species of this genus have a very thick and simple penis wall. A progressive autonomy of the sarcobelum appears to come into being by means of a process of longitudinal scission. In the most specialized slugs the sarcobelum has become fused to the genital atrium.

2. The atrial diverticulum is a glandular appendage of the atrium. In general its gland cells are the same as those in the wall of the atrium. This appendage is sometimes exceedingly well developed, but never secretes a dart.

As to the helicarionids, there seems to exist only one kind of sarcobelum homologous to the first type seen in urocyclids. This organ is rather glandular and consists of a central muscular tube surrounded by a coating of glandular tissue with a retractor muscle.

A penial gland seems to exist among the urocyclids only in the genera *Trochonanina* and *Bloyetia*. These genera constitute a distinct xerophilous tribe characteristic of the East African semi-arid areas.

The genus *Gymnarion* seems to constitute a very distinct group characterized by a peculiar organization of the epiphallus; it does not agree with the scheme found in the urocyclids nor that of the helicarionids.

The marked endemism of some urocyclid genera in the various forest areas of the African continent is an example of the decisive part played by the rain forest in the process of the evolution of these snails.

THE LAND SNAILS OF THE GREER ISLAND NATURE CENTER, FORT WORTH, TEXAS

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The Greer Island Nature Center, approximately 3700 acres, operated by the Fort Worth Park and Recreation Department, is located on the north end of Lake Worth reservoir, in northwestern Tarrant County, Texas. The center includes deciduous forest and grassland plant formations, and the oak woodland which is transitional between them. Four associations occur on the center: Riverbottom Hardwood Forest, Upland Hardwood Forest, Oak Woodland, and Mixed Prairie.

A number of species are common to all wooded habitats in the center. These include *Helicina orbiculata* (Say), *Gastrocopta contracta* (Say), *Strobilops texasiana* Pilsbry and Ferriss, *Catinella* sp., *Glyphyalinia indentata* (Say), *Striatura meridionalis* (Pilsbry and Ferriss), and *Mesodon roemeri* (Pfeiffer).

The Riverbottom Hardwood Forest is a closed canopy forest, with a crown height of about 50 feet and a well developed shrub layer from the ground to 10 feet. Shumard Oak and American Elm are dominants, with Black Walnut, Pecan, and Sugar Hackberry as important constituents. The Riverbottom Hardwoods originally occupied the floodplain of the West Fork

Trinity River, but the alluvial soils had largely been cleared for farming by about 1918 and most of the floodplain has been under water since that date. A few relicts and areas of second growth were sampled and surviving stands below Lake Worth dam were also studied. *Carychium exile* (Lea), *Gastrocopta tappaniana* (Adams), *Vertigo milium* (Gould), *Hawaiia miniscula* (Say), and *Polygyra texasiana* (Moricand) seem to be restricted to this habitat. A single specimen of the introduced slug *Deroceras reticulatum* (Muller) was found in this habitat in the center, but it may also occur in drier habitats. *Punctum vitreum* Baker reaches maximum abundance here, but also occurs in the Upland Hardwood Forest.

The Upland Hardwood Forest is a closed-canopy forest with an average crown height of 40 feet, dominated by Shumard Oak, Post Oak, and Cedar Elm with Chinkapin Oak and Burr Oak as important constituents. It occurs on sheltered hillsides, valley floors, and on the drier alluvial soils at the edge of the floodplain. *Punctum minutissimum* (Lea) and *Helicodiscus eigenmanni* Pilsbry are restricted to this association. Most of the common Western Cross Timbers species range down into the Upland Hardwood Forest, but only *Punctum vitreum* is shared with the Riverbottoms.

The Western Cross Timbers (Dyksterhuis, 1948) is mostly Post Oak Woodland with an average height of about 15 feet, on sandy soil. On a limited area of limestone a much richer association has developed, dominated by a low (15 foot) coppice-forming upland ecotype of Shumard Oak with Post Oak, Black Jack Oak, Live Oak, Bigelow Oak, Cedar Elm, and Mexican Buckeye as important constituents. *Pupoides albilabris* (Adams), *Gastrocopta procera* (Gould), *Helicodiscus nummus* (Vannata), and the introduced snail *Rumina decollata* (L.) occur only in the Cross Timbers. *Rabdotus dealbatus* (Say) occurs in scattered colonies in the drier limestone uplands.

A single specimen of *Deroceras laeve* (Muller) was found in limestone Cross Timbers, but the species may well occur in other habitats as well. *Gastrocopta pentodon* (Say), *G. pellucida* (Pfeiffer), *Helicodiscus singleyanus* (Pilsbry), *Zonitoides arboreus* (Say), *Euconulus chersinus* (Say), and *Polygyra dorfuelliana* Lea are shared with the Upland Hardwood Forest, although they are more abundant in the limestone Cross Timbers. The sandy Post Oak woodland has the same species as the limestone phase, except for the calciphiles *Pupoides* and *Rabdotus*, but the population levels are very low and drier areas, such as hilltops, may be without land snails. Post Oak Woodland with a similar sparse fauna grows on elevated sandy terrace deposits within the floodplain.

Mixed Prairie, The Fort Worth Prairie of Dyksterhuis (1946), occupies the limestone uplands to the east and west of the valley of the Trinity River. Small areas of prairie occur within the center boundary, perhaps 100 acres in all, but these were subject to intensive overuse under grazing leases prior to the establishment of the nature center. No studies have yet been made on the prairie areas within the center. Incomplete studies on climax prairies within a 15 mile radius of the center indicate that the narrow corridors of woodland along prairie streams support a fauna similar to the limestone phase of the Cross Timbers. On the open prairie *Rabdotus mooreanus* (Pfeiffer) replaces *R. dealbatus.*

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VARIATIONS OF THE APERTURE TEETH OF *TRIODOPSIS TRIDENTATA* (SAY, 1816) (POLYGYRIDAE)

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Pilsbry wrote of *Triodopsis tridentata* (1940, p. 796), "In eastern Tennessee and western North Carolina the shells are often rather large, and in the lower slopes of the Great Smoky Mountains the basal tooth is often bifid, or buttressed on the right side." The present author has made five collecting trips to the Great Smoky Mountains National Park and other ranges of the southern Appalachian Mountains. In the field it was noted that some specimens of *Triodopsis tridentata* had bifid basal teeth and others had a single-cusped tooth on the base of the aperture. A check of approximately 400 specimens of *T. tridentata,* in the holdings of the American Museum of Natural History produced the following data: 25% of the snails of this species collected in the "Great Smokies" have a bifid basal tooth, 56.2% are somewhat buttressed on the left or right side of the basal tooth, and 18.7% have a single-cusped tooth on the base of the aperture. The same breakdown of specimens of *T. tridentata* from the entire range of this species yielded the following percentages; bifid: 1.7%, buttressed: 8%, single cusped 90.3%.

Careful examination of the shells of *T. tridentata* revealed the following interesting variations. One specimen from Pittsburgh, Pa. (AMNH 72393) has a bifid outer lip, and a single cusped basal tooth. A shell collected in Madison County, N.Y. (AMNH 72334) has the basal tooth buttressed on the right, and the outer lip tooth buttressed on the left producing an interdental ridge. A second specimen from this lot has the beginning of a second lip on the aperture. From Madison County, N.Y. a snail (AMNH 72334) was collected having two parietal teeth.

In this study, the author observed variations of the relative size of the outer lip tooth and the basal tooth; 27.8% of the shells have a larger basal tooth, 8.8% have the outer tooth larger than the basal, and 63.2% are of approximately the same size. Three specimens from various localities have no lip teeth at all.

Triodopsis tridentata living in the Great Smoky Mountains have a higher percentage of shells with a bifid basal tooth than shells from other parts of the range. The variations of the apertural dentition is variable throughout the range of this species, and seems to be of no taxonomic importance.

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NUDIBRANCHS AND THEIR ALLIES–A 45 MINUTE COLOR MOVIE

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Abstract

Approximately 75 species of nudibranchs and their allies from California and the Gulf of California waters were represented in this film. These nudibranchs range from extremely common species to several that are undescribed.

THE REPRODUCTIVE BIOLOGY OF SOME SOUTH FLORIDA LITTORINIDS

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The rocky shore littorinid species, *Tectarius muricatus, Nodilittorina tuberculata, Littorina lineata, Littorina lineolata,* and *Littorina ziczac,* were shown to be summer spawners in the south Florida region. *Littorina lineolata* spawned from April to the middle of November in 1969, but *Tectarius muricatus* spawned only from late June until the end of August. The other species spawned from the beginning of May through October. An appreciable spawning migration was found only for *Tectarius muricatus.*

A spawning periodicity was found to be correlated with the lunar period and predicted high tide water levels. The best correlation was found with actual high tide water levels. Spawning occurred in one or more species whenever actual tidal levels exceeded Mean High Water Spring Tide levels, during the spawning season.

The species included here released large amounts of spawn. An average-sized female released an estimated: 15,000 egg capsules per season for *Littorina lineata,* 25,000 for *Nodilittorina tuberculata,* 12,500 for *Littorina lineolata,* 44,000 for *Littorina ziczac,* and 36,000 egg capsules for *Tectarius muricatus* in a season. For a square meter of shore having a sizable littorinid population, better than 2,000,000 pelagic egg capsules may be released in a season. It is probable that the importance of the littorinids to their environment is not in their presence on the shore, but in their contribution of planktonic egg capsules, most of which are used for food by other animals.

BIOLOGICAL SYSTEMATICS OF MARINE BIVALVES AND GASTROPODS[1]

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The systematics of shell-bearing marine gastropods has come to be based largely on shell and opercular characters, but also to some degree on pickled (and usually shriveled) bodies, and alkali-soaked, coverslip-flattened radulae. Marine bivalve systematics is based to an even greater degree on shell morphology.

In my view, the time has come for molluscan systematics to become modernized and more broadly based. The title of the Symposium and of this paper ("Biological Systematics") is deliberately redundant because systematics should be an integral part of biology, drawing evidence of phyletic descent and of genetic relationships from a variety of disciplines. The purpose of the Symposium was to show the relevance of, and indeed the necessity for, studies of living animals as an integral part of marine mollusk systematics. The scope comprised life history studies (including sex and reproduction), larval ecology, functional morphology, and adult ecology (including feeding), all of which can enhance and strengthen systematics. Other worthwhile new approaches that were beyond the scope of this Symposium include behavior, genetics, cytology, physiology, biochemistry, and immunology.

The school of functional morphology founded by C. M. Yonge and carried forward by, among others, Alastair Graham and Vera Fretter, considers anatomical structure as it relates to function and mode of life. Another school, founded by Gunnar Thorson, considers larval ecology. Both these schools study living marine mollusks but are not primarily taxonomic in direction or in intent. However, they yield results that are, in my opinion, charged with systematic implications.

Studies of living mollusks are relevant to higher category systematics (functional morphology is particularly useful here) as well as to problems of species and intraspecific variation. The only known sibling species among marine and brackish-water mollusks were discovered in life history studies. Some more specific examples of live animal studies that can advance and extend marine mollusk systematics include the following: 1. The effects of differing foods and other ecologic factors on shell color, size, shape, and sculpture. 2. The structure and function of radulae, and the extent to which structure is determined phyletically or by the food and mode of feeding. 3. The influence of patterns of larval dispersal on patterns of geographic variation. Species with pelagic, planktotrophic larvae are more likely to be widespread and genetically homogeneous than species with lecithotrophic larvae or direct development, which have slower gene flow.

To date, most systematic studies of marine mollusks have been at the superficial, descriptive first stage (alpha taxonomy). There necessarily has been much subjectivity in taxonomic decisions. While there is still need for survey

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[1] Based on the introduction and conclusions to the Symposium held at Key West, Florida, on July 20, 1970.

work, studies such as those advocated here (beta and gamma taxonomy) should provide more objective and therefore reliable bases for future work. The increasing depth, sophistication, and challenge should also attract more interest and support for molluscan systematics.

MAINTAINING FLORIDA MARINE MOLLUSKS IN A NEW YORK CITY APARTMENT

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During a ten year period of maintaining marine aquaria, it has been our observation that, of the 80 molluscan species we have observed for reasonable periods, those that adapted best to captivity have been comparatively small southern gastropods that were collected intertidally (tide pools, rocky areas, sandy shallows). Most were collected in the Florida Keys; all were from areas within the Caribbean Province. In New York they have been kept at room temperature, which is comparable to that of their natural habitat.

Maintenance begins in the field, with careful handling and transport in a fairly wide container, with water only deep enough to cover the specimens and with some material from the mollusk's habitat—coral rocks for the rock dwellers, sand for the sand dwellers, etc. These materials are also carried back to New York to go into the aquaria.

For aquaria we use the clear plastic "vegetable crispers" found in houseware stores. We select oblong ones that have the flange of the lid fitting inside the container. They range in size from one pint (for very small or newly hatched animals) to 1½ gallons, and are easily adapted to receive artificial aeration by filing an opening at the top of a sidewall to permit entrance of an air hose. For the most part we use surface aeration in all but the larger containers, i.e. shallow water having a large surface area exposed to a large volume of air. A general rule is that if the water is deep enough to cover an air stone, use artificial aeration.

The most satisfactory of the sand substrates we have used is the coral/shell mixture from the beaches of the Florida Keys. It apparently supplies some minerals that are helpful, in contrast to the silica or granite sands of more northern beaches. In some small aquaria where no sand substrate is used, a piece of shell or clean coral is introduced.

As all our aquaria are too small to accommodate filters, the water is changed whenever it appears necessary, such as when feces or unconsumed foods have tainted the water, or when the mollusks stay near the surface of the water, indicating some not immediately obvious undesirable condition. This may be quite often for some containers, as rarely as once a month for others. The supply of sea water is stored in plastic jugs after it has been filtered (preferably at the time of collecting but as soon as convenient) through cloth and absorbent cotton to free it of perishable plankton and particles of algae.

To feed the herbivores, we collect algae-covered pebbles for the grazing chitons, ceriths and nerites, and fine-bladed grasses for the *Strombus*. It is soon learned which types of alga are accepted. Almost all the carnivores have

fed readily on *Mytilus edulis* and other northern bivalves; for those feeding on gastropods, *Ilyanassa obsoleta* and *Littorina* sp. are easily provided. An exception was *Aspella paupercula,* which would feed only on live *Arcopsis adamsi* (gratefully received from friends in Florida). Others were *Vasum, Mitra nodulosa, Monilispira* and *Terebra,* whose foods remain unknown to us.

About 40 species laid eggs in captivity; whenever convenient the capsules were isolated in a smaller container for best observation and safety from predators. The young hatching as swimming larvae did not long survive. Of those hatching as crawling young, *Anachis* sp., *Hyalina avena, Muricopsis ostrearum, Pusia hanleyi, Siphonaria alternata* and *Urosalpinx perrugata* were maintained for periods that ranged from a few weeks to two years. *Bailya intricata, Cerithium variabile* [= *C. lutosum*—ED.], *Leucozonia nassa, Murex cellulosus, Nitidella ocellata, Prunum apicinum* and *Thala foveata* ("*Mitra floridana*") were maintained throughout their life cycles. Observations on *Prunum apicinum* were terminated at the sixth generation for lack of space to accommodate the increasing number of specimens. Also observed were the crawling young hatched from field-collected egg cases of *Busycon carica, Busycon spiratum plagosus* and *Urosalpinx cinerea,* and from field-collected adults of *Littorina saxatilis* and *Gemma gemma.*

When a hatch of rock dwellers is expected, small pieces of coral rock are scalded to rid them of worms and anemones, then set aside in filtered sea water to be ready. Newly hatched *Murex cellulosus* crawl into niches of the rock where they tend to remain for several days. Even though they do not feed during this period, new material is added to the shell. *M. cellulosus* starts to feed on the 6th day, drilling tiny bivalves. *T. foveata* starts to feed on the 12th to 14th day, attacking minute gastropods such as newly hatched *Cerithium* and *Siphonaria,* and juveniles of *Lacuna vincta* and *Littorina.* (When these are not available we appeal to our friends in Florida to send us minute *Batillaria.*) As they grow, the young are supplied with increasingly larger prey.

Anachis sp., *Nitidella ocellata* and *Prunum apicinum* fed on *Mytilus edulis* shortly after they emerged from their egg cases, the *Prunum* even attacking live mussel spat. (For sand dwellers such as *Prunum,* a half-teaspoonful of very fine sand in a corner of the aquarium is enough for them to burrow in, and not too much to fan aside to find the young ones.) Unfortunately, suitable food for newly hatched carnivores is frequently unavailable or unknown. The extremely few survivors of some hatches (including *Leucozonia* and *Urosalpinx*) first scavenged dead specimens of their respective hatches before progressing to crushed mussel spat.

Some of each hatch consistently crawl out of water and up the dry walls of the aquarium rather than up the damp rocks provided. Thus a chief chore, besides daily feeding for the first few weeks, is to keep returning the tiny mollusks to a moist environment.

Although the shells of the very young are in beautiful condition, as they grow they show, by erosion and sometimes stunting, that in captivity they lack requirements for their best growth. Dulling and erosion of the shells, varying with the species, is a common complaint of amateur aquarists who do not have a constant flow of water piped in from the sea. In the mollusks we have observed, only *Prunum, Hyalina* and *Neritina* have grown and kept fine shells over a period of years in captivity.

SOME ANATOMICAL AND LIFE HISTORY STUDIES OF WOOD-BORING BIVALVE SYSTEMATICS

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Many features of bivalve mollusks besides shells are important in systematic and evolutionary studies. Striking diversity in anatomy and reproductive features has been observed in marine wood-boring bivalves of the families Teredinidae and Pholadidae. In addition to their systematic value, these features have implications for physiology and ecology.

In the Teredinidae the morphology and arrangement of tentacles on the siphons are often highly characteristic of species. Two possible functions of observed arrangements are the directing of gametes during spawning and the aiding of filter feeding. The pigmentation of siphons also distinguishes some species. When the siphons of most species become known, it should be possible to identify living, undisturbed animals by observing the siphons projecting above the surface of the wood. This would be most useful in studies of the living animals because species identifications could be made without extraction from the wood and without the consequently severe disturbance to the animals. Rapid field-surveys of teredinid populations could be accomplished by SCUBA divers equipped with hand lenses.

The gills of shipworms also show considerable differences in macro-structure and arrangement. In *Teredora malleolus* the gills extend virtually the entire length of the animal, from the mouth to the siphons. In *Nausitora dunlopei* the gills are extremely reduced, extending only over the posterior one-fifth of the animal's body length. Most other species have gill lengths intermediate between these extremes. The differences in gill lengths may indicate varying dependencies on filter feeding among different species.

Feeding is also related to another important anatomical feature of shipworms, the caecum. The caecum is a large accessory digestive pouch. Generally the size of the caecum varies inversely with the size of the gill. Probably much of the digestion and/or absorption of woody materials occurs in the caecum. A prominent typhlosole found there undoubtedly plays a major role in these processes. Two very different forms of the typhlosole, seen in cross section, have been observed in the few species examined so far. In *Bankia gouldi* the typhlosole is small and has a sprig-like appearance in cross section. In *Teredo navalis* it divides into two large spirally coiled arms. The typhlosole of *Lyrodus pedicellatus* closely resembles that of *T. navalis.*

Reproductive strategies in the Teredinidae range from fully planktotrophic development of larvae to complete brood protection. Planktotrophic species may be able to delay metamorphosis for long periods. Unidentified teredinid larvae have been found by Dr. Rudolf Scheltema throughout the North Equatorial Current in the Atlantic. Most brooding species release pediveliger larvae which are able to penetrate wood almost immediately. In the brood-protecting species *Lyrodus pedicellatus, Teredo bartschi,* and *T. furcifera,*

pediveliger larvae lose their swimming ability a few days after being released, and metamorphose in the absence of wood. Thus dispersal of these species may be accomplished primarily by adult populations in floating wood. In a few species, such as *Teredo navalis* and *Lyrodus massa,* brood protection is not complete, and larvae are released in the straight-hinge stage. An intriguing case of intraspecific vàriation in larval ecology has been noted for *Lyrodus pedicellatus.* Individuals of this species in Puerto Rico released viable straight-hinge larvae. In all other cases known, this cosmopolitan species has released viable larvae only in the pediveliger stage.

Some recent advances in the systematics of the Pholadidae (subfamily Xylophaginae) have resulted largely from new knowledge of anatomy and reproductive biology.

Xylophaga atlantica from the western Atlantic and *X. washingtona* from the eastern Pacific were originally placed in the same species group on the basis of the dorsal plate, but when whole animals were obtained, the siphons of the two were found to be quite different. In *X. atlantica* the excurrent siphon is only slightly shorter than the incurrent, is separate from it at the posterior end, and the apertures of both siphons are surrounded with papillae. In *X. washingtona* the excurrent siphon is truncated; its aperture lies at the end of a short tube between two lappets which extend along the dorsal surface of the incurrent siphon. The aperture of the excurrent siphon lacks papillae, while the incurrent siphon has a single row of papillae.

More recently, *Xylophaga clenchi,* also from the western Atlantic, was confused with *X. atlantica.* However, this pair could also be distinguished on the basis of the siphons. In *X. clenchi* the siphons are short, the excurrent aperture small with two large papillae on each side. The incurrent siphon has a double row of papillae, an inner large row and an outer small one.

Neither *Xylophaga atlantica* nor *X. washingtona* brood their young. However, the young of *X. clenchi* are carried on the back of the adult's shell to the late umbo stage.

Xylophaga atlantica is primarily a continental shelf species, extending from Newfoundland to Virginia at depths from 15 to 600 meters. *X. clenchi* has been found at greater depths, ranging from 300 to 1836 meters, between Iceland and Venezuela. This latter species has recently riddled lobster traps at depths of 300 to 600 meters in Hydrographers' Canyon off Rhode Island.

All known brooding species of *Xylophaga* occur in deep water. Nonbrooders, including *X. dorsalis* and *X. praestans* of Europe, *X. atlantica* (western Atlantic), and *X. washingtona* (eastern Pacific), all occur in relatively shallow water.

In summary, the genus *Xylophaga* may be divided into six species groups on the basis of the structure of the dorsal plate, the siphons, and the presence or absence of brood protection.

COMPARATIVE BIOLOGY OF TWO CORAL-EATING NUDIBRANCHS (GASTROPODA) OF THE GENUS *PHESTILLA* BERGH, 1874

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Many nudibranchs are obligately associated with one to a few species of prey organisms. In order to understand better the morphology and biology of such nudibranchs, it is important to consider them as members of intimate associations. Differences between nudibranch species may often be correlated to the differences between their respective associations. This can be illustrated by the two aeolid nudibranchs in the genus *Phestilla.*

Phestilla melanobrachia Bergh, ·1874, and *P. sibogae* Bergh, 1905, feed on scleractinian corals in the families Dendrophylliidae and Poritidae respectively. Many of the differences between these two similar species are related to the characteristics of their respective coral prey.

The external morphology of the *Phestilla* species reflects the structure of their food corals. *Phestilla melanobrachia* has long cylindrical cerata which are similar in form to the long tentacles of the large polyps of dendrophylliid corals, while *P. sibogae* has shorter, knobbed cerata that lie against the flattened substrate of small-polyped *Porites* spp. corals.

Both *Phestilla* species are cryptically colored with respect to their host corals. Laboratory experiments and field observations show that the nudibranchs derive most of their pigmentation directly from the corals on which they feed. *Phestilla melanobrachia* uses four types of pigments, depending on the species of coral eaten. The first is a red carotenoid, with properties similar to astaxanthin, which is accumulated in the epidermis and salivary glands and is permanent in these tissues once deposited. The second pigment is a black, granular material which is probably a melanin and is limited to the digestive gland cells in the cerata; it too is permanent. The third consists of one or more yellow, water-soluble pigments with properties which suggest flavones; these pigments are limited to the digestive gland cells and are not permanent. The fourth group of pigments are those present in the zooxanthellae from the hermatypic dendrophylliid coral, genus *Turbinaria,* which pass through the digestive gland in the cerata as they are digested. It is evident that *P. melobrachia* may vary greatly in its coloration depending on the color of the coral or corals on which it has been feeding. Therefore, freshly metamorphosed nudibranchs may be cryptically colored on a variety of coral species. *Phestilla sibogae* utilizes concentrations of reflecting granules in the epidermis in combination with the zooxanthellae from *Porites* spp. for its coloration.

Embryonic development time of the two species is quite similar, taking approximately six days from laying to hatching of the veligers. The veliger stage of *P. melanobrachia* is planktotrophic and the veligers must feed for about eight days before they are ready to settle. *Phestilla sibogae* veligers are lecithotrophic, and the non-feeding veligers are ready to settle three days after hatching.

Most dendrophylliid corals have a photonegative distribution and are found in shaded habitats; veligers of *P. melanobrachia* become photonegative when ready to settle. In contrast, *P. sibogae* veligers become photopositive when ready to settle, which conforms to the distribution of hermatypic *Porites* spp. The veliger stages of each *Phestilla* species require the presence of some chemical factor from living coral prey tissue in order to undergo metamorphosis.

The two *Phestilla* species differ from most aeolid nudibranchs in that they do not store nematocysts. Instead of cnidosacs, at the tips of the cerata are secretory glands which give off droplets of a clear, highly viscous material when the nudibranch is disturbed. There are also unicellular secretory glands concentrated at the tips of the cerata in the epidermis that release their contents in response to attack by predators.

Field and laboratory experiments show that the cerata are distasteful to potential predators such as fish and crabs. There appears to be an inverse correlation between the relative distastefulness of the *Phestilla* spp. and the predation pressure on their respective coral hosts. Few organisms were observed to eat dendrophylliid corals, while a number of species of fish, starfish and gastropods were found to attack *Porites* corals. Fishes tested in the laboratory and in the field were much more likely to eat *Phestilla sibogae* than *P. melanobrachia.*

The studies on *P. melanobrachia* were conducted at the University of Singapore and at the Hawaii Institute of Marine Biology during the period January, 1967 to April, 1969, while *P. sibogae* was studied in Hawaii from October, 1968 to April, 1969.

Personal observations on numerous nudibranch associations have convinced the author that, in addition to providing a better understanding of individual species, studies of the associations of closely related species and genera should provide important insights into the evolutionary relationships and trends within the Nudibranchiata.

POSSIBLE VARIABILITY IN LARVAL DEVELOPMENT BETWEEN POPULATIONS OF THE CEPHALASPID OPISTHOBRANCH *ACTEOCINA CANALICULATA* (SAY)

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Acteocina canaliculata (Say) is a west Atlantic temperate infaunal species occurring in shallow bays and estuaries of low to variable salinity from southeastern Canada south at least to the Gulf of Mexico. Wells and Wells (1962) reported direct development in a population of this species from Pamlico Sound, North Carolina. My studies on a population from eastern Connecticut reveal that at this locality development involves a planktotrophic veliger stage. Oviposition occurs from May through September with a peak in late June and early July. The egg masses, containing 200–700 eggs, are attached by a mucous strand which is anchored beneath the surface of the mud.

The ova vary in diameter from 85 to 105 microns. They occur singly in capsules and hatch in 4–6 days at 18–20 degrees C. The newly hatched veligers average 154 microns and are morphologically typical of other "Type 1" opisthobranch larvae (Thompson, 1967) with the exception that a single eye is present. When fed unialgal cultures of *Isochrysis galbana* or *Monochrysis lutheri*, the larvae grow rapidly and metamorphosis occurs at larval shell diameters of 290–300 microns, in eight to nine days at 25 degrees C. Unfed larvae grow significantly though at a lower rate but never exceed 210 microns and are unable to complete development. During development, the larval shell undergoes increasing asymmetry, from an isostrophic condition at hatching to a markedly hyperstrophic condition at metamorphosis. Internally, major developments leading to metamorphosis include enlargement of the foot, enlargement of the mantle cavity including the appearance of the adult heart, and the appearance of the second eye. Metamorphosis is preceded by a period of crawling during which the pediveliger does little swimming. Metamorphosis is a gradual but fairly rapid process involving the resorption of the velum. Development from the hyperstrophic post-veliger stage to the orthostrophic juvenile occurs over a period of several weeks in the laboratory although possibly faster in the field.

Collections of living *Acteocina* egg masses and adults from New England to North Carolina made by the author reveal a planktotrophic mode of development at each location. However, a cephalaspid egg mass was collected from Avon, North Carolina (Pamlico Sound), which contained a small number of relatively large, direct-developing eggs corresponding to those described by Wells and Wells. Although this species is presently unidentified, the embryonic shell at metamorphosis consists of a complete larval shell of 1–1½ whorls and is thus significantly different from other known direct-developing cephalaspids. This may represent a less specialized, intermediate stage in the evolution of direct development in cephalaspid opisthobranchs.

The existence of both planktotrophic and direct-developing populations of *A. canaliculata* suggest either poecilogeny (intraspecific variability in mode of development) or cryptic species.

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EVOLUTION OF THE TOXOGLOSSATE RADULA AND METHODS OF ENVENOMATION

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The name "toxoglossate" applies to several families of carnivorous gastropods capturing prey by injecting poison with highly specialized radular teeth. Traditionally, the families Conidae, Terebridae, and Turridae are included

in the group although it is known that many species in the latter two families do not have barbed, hypodermic, needle-like teeth and others completely lack venom apparatus and radula.

Since 1928, when Risbec found a toxin apparatus in various Indo-West Pacific species, the Mitridae have sometimes been considered toxoglossate. So also have the Marginellidae and Cancellariidae. The Mitridae and Marginellidae do not inject their poison, and I have not investigated the feeding of Cancellariidae. These three families are not here considered toxoglossate. However, a poison apparatus which may be prototypic of the toxoglossates is found in the Mitridae. A convoluted tubelet in the anterior part of an extensible muscular sheath may be homologous with the toxoglossate venom gland and muscular bulb respectively. In *Mitra nodulosa* (Gmelin, 1791), the apparatus rests beside the buccal mass and radula. The unarmed tip extends beyond the proboscis mouth and far beyond the radula during attack. The toxin, deposited by a touch of the tip against the soft parts of the prey, permeates unbroken epidermis.

The poison apparatus in the Mitridae opens anteriorly, while in all toxoglossates it opens into the buccal cavity posterior to the opening of the radular sac. Poison must flow over or around the tooth or teeth into the prey. In the case of some, such as the turrids Clavinae or Turrinae, actual envenomation probably takes place in the buccal cavity after living prey has been swallowed. In others, and in all Conidae, a single tooth is squeezed from the radular sac through the cavity until the base of the tooth is held by the sphincters at the tip of the proboscis. This tooth is probably charged with poison as the armed proboscis is extended to harpoon the prey.

The effect of the poison, general ataxia and paralysis, is the same in Mitridae, Marginellidae, and all the toxoglossate families.

By discussing the possibly prototypic poison apparatus in the Mitridae, I do not infer that the toxoglossates were derived directly from that family. The Mitridae and all three toxoglossate families were well represented in the earliest Eocene faunas. Their common ancestor was pre-Cenozoic.

Study of the toxoglossate radula suggests that this common ancestor may have been a mesogastropod with a radular formula of 2.1.1.1.2. I believe this because of the duplex nature of the marginal teeth of many groups of the Turridae. The harpoon teeth of the terebrid *Hastula cinerea* (Gmelin, 1791) and of *Conus regius* Gmelin, 1791, also show signs of a duplex origin.

Feeding snails have adapted this formula to their needs during the past 70,000,000 years or so. Teeth, or parts of teeth subject to stress strengthened or enlarged. Those not used tended to weaken or disappeared. When the radula was used for rasping, or was used within the buccal cavity, the subradular ribbon persisted in a conventional manner. The main function of the underlying ribbon in harpooners like *Eucithara* or *Conus* changed to one of confinement, i.e., the radular pouch.

One does not expect or find much "straight line" evolution in the dentition of such highly specialized feeders. But the Turridae and other groups each have a characteristic pattern of experimentation. The Clavinae (of Maes unpublished, not of Powell, 1966) seem to have lost the lesser marginal tooth in all forms examined, and most have kept a strong but small central. Changes

have occurred in the rachiglossate-like lateral teeth and in the length of the shaft of the major marginal.

The Turrinae, Turriculinae and Clavatulinae (if indeed they are separate subfamilies) have lost the lateral teeth and may or may not retain the central in obviously (on the basis of shell and other radular characters) closely related species. The lesser marginal is always fused to the tip of the greater, forming the "wishbone" marginal which varies greatly in size, stoutness, and the angle of the two limbs.

In the Crassispirinae (in part of Morrison, 1966), on the other hand, the central tooth has been permanently lost, but vestigial, uncusped lateral teeth may be found in several species. Experimentation in this group has largely been with the unequal marginal teeth. These may be almost as solid and fused as in some Turrinae or they may be sliver-thin and lightly joined at the tip and base. The latter hint the origin of the typical rolled toxoglossate marginal teeth.

Typical toxoglossates, such as *Eucithara* in the Turridae, *Hastula* in Terebridae, and *Conus* have completely lost the central and lateral teeth. Whether the broad but very thin major marginal is partially rolled around and fused with the slender minor marginal, or whether the latter has been lost, is arguable, particularly in Conidae which are not as well known to me. The degree of ornamentation of these rolled teeth is highly variable. The radular ribbon, which shows some variation in other groups, particularly the Crassispirinae, changes in a most interesting manner.

This change is better understood by reviewing the history of a single row of teeth on the radula of a rasping gastropod such as *Lymnaea* or *Helix* (Pulmonata) (Runham, 1963). Teeth and ribbon are layed down by cells in the posterior part of the radula sac. As they pass forward they are tanned and hardened by surrounding tissue. Fully hardened, they pass anteriorly to the "working bend" at the opening into the buccal cavity. Here the teeth, erected by a U-shaped bend of the ribbon, are used a row at a time. Passing below, worn teeth are sloughed off by changes in the cells of the membrane and are lost.

In the *Conus*-like toxoglossates, however, there is no opening at the "working bend." Pairs of hardened but unused teeth pass below the bend and are sloughed from a vestigial subradular membrane. But instead of being lost, they are stored in a membraneous pouch (part of the subradular epithelium?) which opens narrowly into the buccal cavity. A single tooth is squeezed through this opening to arm the tip of the proboscis as needed.

The phylogeny of a few toxoglossate snails, particularly in the Turridae, has been clarified by these studies. The way in which the radula and toxin apparatus has been adapted for specialized feeding habits has indicated some relationships not previously suspected. However, these apparent relationships must be demonstrated by other characters of shell and soft-parts and in more species of various groups before a major revision is undertaken.

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FEEDING MECHANISMS IN THE FAMILY TEREBRIDAE

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Terebrid gastropods are one of the most abundant components of tropical marine sand communities, but one of the least studied biologically. All terebrids have auger-shaped shells and all are restricted to the sand habitat. The purpose of my research over the past few years has been to study the ecology and life histories of terebrids from the Indo-Pacific, Eastern Pacific, and Western Atlantic provinces.

As a side project I have been developing a new classification of the family based on soft anatomy and life histories as well as shell shape and sculpture. The most important diagnostic character in this revised classification is the nature of the proboscis apparatus and the method of feeding. The terebrid proboscis does not consist of one eversible component as is the case for most gastropods, but has been completely divided into two separate functional components, an anterior labial tube and a posterior buccal tube, both of which may serve as an introvert during feeding. (A complete definition of terminology has been submitted to The Veliger for publication.)

Significant structural differerces occur among the probosces of terebrids, particularly in the morphology of the buccal tube and the number and type of buccal organs present. I have used these differences to classify the family in five feeding types. Species of a particular feeding type are not only similar in morphology, but also in behavioral characteristics, habitat preferences, and other aspects of life history. Important differences are seen, however, when species of one feeding type are compared with those of another. I believe that these differences are of taxonomic significance, and can be used to separate several genera.

Type I species, of which there are two kinds, have a long labial tube and a short buccal tube. Buccal organs are limited to a pair of salivary glands. They have no poison gland and hence are incapable of rapid prey immobilization and capture. All species I have studied live subtidally in extensive sand flats.

Type IA terebrids are specialized to feed on slowly moving prey, all known species selecting hemichordates. Feeding is elicited by contact of the propodium of the foot with the prey. The labial tube everts, enters the hemichordate burrow, and grasps the worm. As the labial tube retracts, pulling the worm into the labial cavity, the buccal tube then grasps the worm and pulls it in farther. This sequence is continued until the prey is completely ingested. Feeding occurs on or just under the surface of the sand, and the snail does not pursue the prey deeply into its burrow.

Type IB terebrids have an extremely long labial tube and a broad fleshy

foot specialized for deep burrowing in the sand. All type IB species feed on capitellid polychaetes living in loosely compacted sand. When these species contact a capitellid in its burrow, the foot digs down and pulls the shell into the sand at a 90 degree angle. At the same time the long slender labial tube everts, enters the capitellid burrow, and extends into the burrow until it grasps the prey. Feeding is then similar to that of Type IA.

Species with the Type II proboscis are the only terebrids exhibiting typical toxoglossan characteristics. They have a long retractile buccal tube, and contain within the cephalic hemocoel a poison bulb, poison gland, and two rows of harpoon-like radular teeth. There are two kinds within this type.

Type IIA terebrids occur in great abundance on surf-washed beaches throughout the tropics. Some species live in the surf zone, occupying the same microhabitat as *Donax*, and others are found just beyond the breakers. Prey is initially detected by distance chemoreception and this is sufficient to elicit labial tube eversion. When the propodium of the foot comes into contact with the prey, the labial tube everts completely and begins scanning movements over the sand. The buccal tube holding the radular tooth everts at the same time, and when contact is made with the prey, the animal lunges, the tooth is injected, and poison flows into the wound. The labial tube then engulfs the prey, and the snail burrows into the sand to complete feeding. Prey capture is usually completed between the passage of two successive waves.

Type IIB species differ significantly from the Type IIA. All have a small foot, live in deep calm areas, are very secretive, and use the small poison apparatus to immobilize the prey, thus preventing it from retracting into its burrow. The animals are slow-moving and do not burrow deeply into the sand during feeding. Most feed on small tube-dwelling polychaetes.

Type III species lack the radular apparatus, as is the case for Type I terebrids, and many have lost the salivary glands and buccal tube as well. They differ from all other terebrids in that they have an accessory feeding organ contained in the labial cavity. This organ differs in structure and function from the boring organ of naticids and muricids, and has not been described before in any gastropod.

The organ consists of a long posterior glandular and muscular stalk, terminating anteriorly in a series of muscular papillae. I have not been able to feed the animals in the laboratory, but results of gut analyses and observations in the field indicate that the animals use the feeding organ to grasp the tentacles of cirratulid polychaetes and pull them into the labial cavity. Gut analyses indicate that digestion begins in the labial cavity, and the partly digested worm is passed to the buccal cavity by the accessory organ.

How can these feeding types be used in a more meaningful classification of the family? I do not intend to make any recommendations as to which generic names should be used, but will merely point out the feeding types that should be given generic status.

I would place all terebrids with the Type I feeding apparatus into one genus, primarily on the basis of internal morphology and similarities of life history. Shells in this group are weakly sculptured, have a wide aperture, and generally are large and heavy with a small number of whorls.

On the basis of shell morphology alone I would suggest that all Type IIA terebrids show evidence of descent from one ancestral type. These all have

small shiny shells with few whorls and a flared aperture. Based on similarities in internal morphology and life history as well, I conclude that the animals are sufficiently different to include them all in the genus *Hastula,* as is now done by many workers.

Type IIB species appear to be closely related. All have a long slender shell with many whorls, a constricted aperture, and a sinuated lip. This feeding type includes *Terebra subulata,* the nominal species for the genus, so I have included all Type IIB terebrids in the genus *Terebra. Terebra subulata* was erroneously described by Lamarck as lacking a radula.

Species with the Type III feeding apparatus are easily distinguished on the basis of shell characteristics. While it is possible that they may eventually be divided into more than one genus, I suggest for the present that they be included under one genus, possibly *Myurella,* as suggested by Adams and Adams, 1858.

REPRODUCTION AND DEVELOPMENT IN FLORIDA *CERITHIUM*

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The life histories of *Cerithium muscarum, C. variabile* [= *C. lutosum*—ED.], *C. eburneum, C. litteratum,* and *C. auricomum* were investigated. The Cerithiidae have open genital ducts, are aphallic, and lay their eggs in gelatinous strings or tubes attached to the substratum either as a tangled mass or a flat coil. Their mode of reproduction and development is of two kinds. The first occurs among the more stenohaline species: *C. floridanum, C. litteratum, C. eburneum, C. algicola* and *C. atratum,* and is the most common kind seen by past workers (Lebour, 1945; Marcus, 1964; C. C. Davis, 1967) and in the present study. There are many eggs, rapid cleavage and attainment of the veliger stage, a short incubation period, and emergence of the larvae as free-swimming planktotrophic veligers. This is the type of development described for the closely related genera *Bittium* (Fretter and Graham, 1962), *Cerithiopsis* and *Triphora* (Lebour, 1933; Fretter, 1951).

The second pattern was seen in the two more euryhaline species, *Cerithium variabile* and *C. muscarum,* and involves fewer but larger eggs, slower development, and a lengthy incubation period within the egg capsules, the young emerging only when completely metamorphosed. In the case of *C. muscarum,* this involves the production of spermatophores, which have never before been recorded in a marine member of the superfamily Cerithiacea. Spermatophores of *C. muscarum* closely resemble those described for *Goniobasis* in the freshwater family Pleuroceridae (Cerithiacea) by Woodard (1934; 1940) and Dazo (1965).

Sperm transfer was not observed in any other of the species. All species examined had both eupyrene and apyrene sperm. The spawn of the Florida species studied is similar to spawn described for cerithiids in other parts of the world. The egg masses of the closely related genus *Cerithidea* are also similar.

Aspects of the reproduction and development were compared with the observations on West Atlantic species by other workers.

SEXUALLY DIMORPHIC ARCHAEOGASTROPODS AND RADULAE

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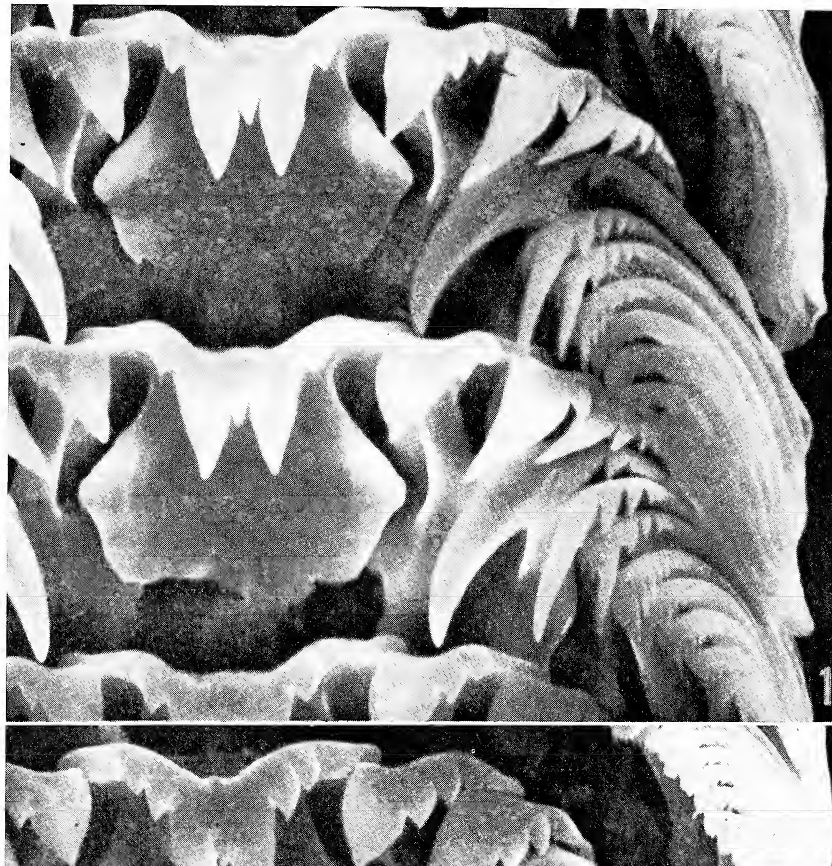
Both the shells and rhipidoglossate radulae of *Hiloa* Pilsbry, a subgenus of *Tricolia* Risso (Trochacea: Phasianellidae), are sexually dimorphic. Sexual differences in the sizes and shapes of archaeogastropod shells are already known [H. B. Baker, 1926:52–54, *Viana*; Lamy, 1937:296–297, review of other cases], but the shape differences reported herein are dissimilar. Previously, sexually dimorphic radulae have been convincingly reported only in the widely unrelated neogastropod (rachiglossan) families Muricidae (*Drupella, Nassa* [alias "*Iopas*"], and possibly *Mancinella* and *Vexilla*) [Arakawa, 1958, 1964; Maes, 1966], and Buccinidae (*Pisania luctuosa* Tapparone-Canefri) [Cernohorsky, in press].[1]

Hiloa is restricted to shallow water and ranges from East Africa to the Hawaiian and Cook Islands, north to Honshu, Japan, and south to New South Wales, Australia. Male shells are smaller than female shells and unlike females have flared outer lips and consequently enlarged apertures. Males and females have been considered different species, and so also have color forms in this notoriously polychromatic group. In both sexes there is substantial geographic variation in maximum attained shell sizes. The largest sizes occur in Japan (maximum observed shell lengths: 3.5 mm in males and 5.2 mm in females), and the smallest sizes in the Seychelles (maximum lengths: 1.3 mm in males and 1.8 mm in females) and Cocos-Keeling Islands. The allopatric forms of *Hiloa* show clinally continuous variation and the distinctness of populations reflects their geographic isolation. A pelagic larval stage is suppressed, and populations at islands surrounded by deep water are semi-isolated. Large samples collected from algae are available from some localities, and these include numerous juveniles. The sex ratio is curiously disparate: only 32 to 23 percent of all adults are males.

Except for Japanese populations (in which radular dimorphism is indistinct), male *Hiloa* radulae have about half as many marginal teeth per transverse row as do females. The actual numbers correlate with shell size. The illustrations show right halves of two transverse rows of teeth from each sex in a fairly large-shelled population of *Tricolia* (*Hiloa*) *variabilis* (Pease) at Kauai, Hawaiian Islands. The male (Fig. 1) has 8 marginals, the inner of which are pointed distally; the female (Fig. 2) has 16 marginals, the inner of which are digitately cusped. The cusps of the median and three lateral teeth are narrower in the male than the female. In the large-shelled Japanese specimens the maximum observed numbers of marginals are 43 in males and 51 in females. In

[1] A nassariid (*Nassarius* [alias "*Nassa*"]) once was suggested to have sexually dimorphic radulae but this was later shown to be wrong. According to Maes (1966) they may occur in the Fasciolariidae. Recently, a heteropod (*Atlanta inflata* "Souleyet" [Orbigny?]) has been reported to have sexually dimorphic taenioglossate radulae [Richter, 1969:353–354, fig. 3]; I think the evidence is unconvincing. According to Arakawa (1969 and *in litt.*), Mr. H. Elton Woodward [Florida State University] has found sexually dimorphic radulae in a cymatiid; according to Woodward himself (*in litt.* to Hal Lewis) there is no evidence for this.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the small-shelled population at the Cocos-Keeling Islands (and probably also at the Seychelles) the corresponding numbers are 3 in males and 8 in females. These small-shelled males have the fewest teeth per whole transverse row known in any rhipidoglossate radula: 13. The number of marginals increases ontogenetically, but all juveniles and young males have the same cusp morphology as mature females.

What are the reasons for sexual dimorphism in *Hiloa* radulae? The sexual differences in size and shape of the shells do not seem to account for the radular dimorphism. *Hiloa* lives preferentially on the brown alga *Padina*, and preceding and during the breeding season males live on top of the shells of females (Wertzberger, 1968). Most *Hiloa* shells are incrusted with calcareous algae. The radular dimorphism could be due to the males feeding on calcareous algae while the females feed on *Padina* and the epiphytes and detritus thereon. The different radula morphologies may be selectively advantageous for these different foods.

Sexually dimorphic radulae are not known in phasianellid taxa other than *Hiloa*, and the occurrences in *Hiloa*, muricids and buccinids may be altogether exceptional. One similarity is noteworthy: male *Hiloa*, *Drupella* and *Pisania luctuosa* radulae all have fewer teeth (transversely or longitudinally) than corresponding females. Dimorphism needs to be considered in all future radular studies of dioecious gastropods.

ACKNOWLEDGMENTS

Taxonomy of the Phasianellidae is treated in a soon-to-be-published monograph in "Indo-Pacific Mollusca." The scanning electron microscopy was supported by National Science Foundation Grant GB-7008.

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Scanning electron microscope photographs of the sexually dimorphic radulae of the phasianellid *Tricolia* (*Hiloa*) *variabilis* (Pease). Specimens from Kauai, Hawaiian Islands. The right halves of two transverse rows from each sex are shown at a magnification of ca. ×1200. Fig. 1 is a male and Fig. 2 a female.

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REMARKS ON SHELL MORPHOLOGY

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Abstract

Dr. Bruce Miller and I are approaching the problem of a workable generic separation of the Terebridae from different angles. Mine is based on shell morphology. The genera proposed for this family in the past are impractical, being based for the most part on shell characteristics which are variable within many species. There are shell characteristics which do not vary within a species of this family: shape of nucleus; interior columella; shape of whorl outline (concave, straight, convex); lamination of the columella. My hope is that a combination of some of these unvarying features will correlate with the work Dr. Miller is doing on animal morphology to produce a really sound basis for generic division.

A STUDY OF THE GROWTH RATE AND LONGEVITY OF THE NAIAD *AMBLEMA PLICATA* (SAY, 1817) IN LAKE ERIE (BIVALVIA: UNIONIDAE)

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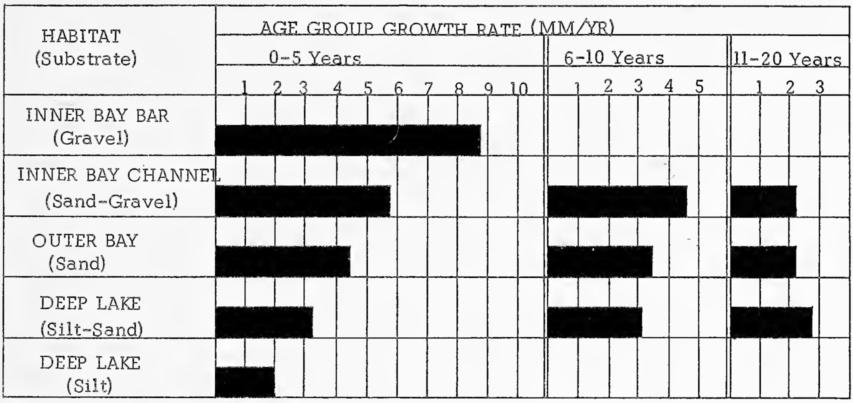
Although studies of the age and growth of domestic animals and wild animals of economic importance are rather commonplace, there exist a number of animal species which man has either not studied in this regard or has limited his observations to a relatively few unsatisfactory measurements. This condition was true of fresh water bivalves in general until many of the commercially valuable species were harvested to a point dangerously near extirpation by collectors for the button industry and pearl-seekers.

The first indication of the depletion of this natural resource prompted government sponsored studies of these forms in the first several decades of this century and resulted in valuable studies by Lefevre and Curtis (1912), Isely (1914), Coker et al. (1921), Grier (1922), and, most especially, by Chamberlain (1931). Chamberlain used the annular ring method to demonstrate growth rate and longevity in several unionid species and went further to note differences in growth rate in different populations of the Yellow Sand Shell, *Lampsilis anodontoides,* due apparently to differences in habitat.

Grier (1922) first noted the unusual regularity of the annular rings in Lake Erie naiads and Stansbery (1967) took advantage of this characteristic in

MEAN GROWTH RATES OF AMBLEMA PLICATA (SAY) IN

LAKE ERIE IN RELATION TO HABITAT



deriving generalizations about growth variation in the lake fauna relative to both habitat and classification.

This study is an attempt to investigate variation in the growth and longevity of a single species as affected by differences in habitat in a relatively small area. Data were collected from specimens taken from five different habitat areas in the Bass Island region of Western Lake Erie. These sampling sites included: 1) Deep Lake (silt bottom); 2) Deep Lake (fine sand bottom); 3) Fishery Bay, Outer Bay (silt bottom); 4) Fishery Bay, Inner Bay Channel (coarse sand bottom); and 5) Fishery Bay, Inner Bay Bar (gravel bottom).

Mean lengths for each year of growth for each habitat were calculated from measurements taken from the specimens. These means, along with their respective extremes, were plotted on graph paper giving a growth curve for each habitat sampled. The growth rates for the different habitats were compared on the basis of age periods since it was observed that the rates decreased differently with age. Rates of growth of specimens during their first five years of life were slowest in the fine sediment substrates in the deepest water. The most rapid rates during this early growth period were exhibited by mussels from coarse sediments in shallow water. Although all rates decreased during the second five year growth period, the rate of the deep-water, fine-sediment specimens decreased least so that the rates become more nearly the same. In the third and fourth five-year periods the rates of the deep lake specimens continued to decrease at a relatively slower rate. This resulted in those specimens (deep lake) which exhibited the lowest initial growth rate having, after ten years of growth, the greatest relative growth rate at that time. Rates in the study varied from a low of 2.4 mm/yr to a high of 8.8 mm/yr. The general inference is that those individuals living in the deeper water, and finer sediments (factors associated with reduced current) grow slower, undergo less change in growth rate during their lives, and live longer. The oldest specimen aged was estimated to be 32 years of age and was living at the time collected.

COCHLIOLEPIS PARASITICA, A NON-PARASITIC MARINE GASTROPOD

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Abstract

Cochliolepis parasitica has a typical rissoacean snout, radula, and crystalline style. There is no structure present suggesting parasitism on the host worm. The systematic position of the genus is also discussed.

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Cynthia Plockelman, West Palm Beach, Florida
Mr. and Mrs. Hugh J. Porter and son, Morehead City, North Carolina
Mr. W. Lloyd Pratt, Jr., Fort Worth, Texas
Dr. Thomas E. Pulley, Houston, Texas
Mrs. Dorothy Raeihle, Elmhurst, New York
Mr. and Mrs. William K. Reader, St. Petersburg, Florida
Mr. and Mrs. Duane C. Riel, South Milwaukee, Wisconsin
Dr. Robert Robertson, Philadelphia, Penn.
Dr. Catherine H. Robins, Miami, Florida
Mr. Howard Root, West Palm Beach, Florida
Mr. John Root, West Palm Beach, Florida
Dr. John W. Ropes, Oxford, Maryland
Mr. and Mrs. Howard Rosentreter, Big Pine Key, Florida
Mr. William A. Ross, West Palm Beach, Florida

Dr. Henry S. Russell, Dover, Mass.
Mrs. Frieda Schilling, St. Louis, Missouri
Mr. John Gunn Seville, Dunedin, Florida
Miss Violet A. Seville, Dunedin, Florida
Dr. Carl N. Shuster, Davisville, Rhode Island
Mrs. Lula B. Siekman, St. Petersburg, Florida
Dr. and Mrs. Ralph M. Sinclair and children (3), Cincinnati, Ohio
Dr. Carl Sinderman, Miami, Florida
Mr. and Mrs. H. P. Snyder, McKeesport, Penn.
Dr. and Mrs. Alan Solem and son, Chicago, Illinois
Mr. Gale Sphon, Los Angeles, California
Mrs. Katheryn Sphon, Los Angeles, California
Dr. and Mrs. David H. Stansbery and children (2), Columbus, Ohio
Mr. and Mrs. Dan Steger, Tampa, Florida
Mr. and Mrs. Dale V. Stingley, La Belle, Florida
Mary Lou Stoner, Ft. Lauderdale, Florida
Mrs. H. Brown Sturgeon, Miami, Florida
Miss Barbara Sutton, New York, New York
Mr. and Mrs. Albert Taxson, Bronx, New York
Mrs. Jud Taylor, San Antonio, Texas
Mrs. Renford Taylor, San Antonio, Texas
Mrs. Margaret Teskey, Big Pine Key, Florida
Mr. Foster B. Thorpe, Ft. Lauderdale, Florida
Mr. and Mrs. G. W. Torrance, St. Petersburg, Florida
Dr. Jean-Jacques van Mol, Brussels, Belgium
Dr. Thomas E. Waller, Bethesda, Maryland
Mrs. Germaine L. Warmke, Gainesville, Florida
Dr. Henry G. Wehringer, Northbrook, Illinois
Miss Isabelle E. Welch, Falls Church, Virginia
Mr. Milton O. Werner, Brooklyn, New York
Mr. and Mrs. Adlai Wheel, Syracuse, New York
Mrs. Smith Whiteside, Durham, North Carolina
Mr. and Mrs. Carl C. Withrow, St. Petersburg, Florida
Mrs. Toni Wood, River Forest, Illinois
Mr. Calvin T. Wright, Assanet, Mass.
Dr. and Mrs. Paul Yokley, Florence, Alabama
Miss M. E. Young, Falls Church, Virginia
Mr. and Mrs. John Young, Marathon, Florida

THE AMERICAN MALACOLOGICAL UNION
EXECUTIVE COUNCIL
1970–1971

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HONORARY LIFE PRESIDENT

S. Stillman Berry

AMERICAN MALACOLOGICAL UNION
ANNUAL BUSINESS MEETING

The meeting was called to order by President Alan Solem as part of the final session of the thirty-sixth annual meeting of the American Malacological Union.

The annual report of the AMU Secretary was read:

"Over the fiscal year of 1969, 115 new members had been enrolled, 4 resigned, 4 died and 64 were dropped for delinquent dues. On January 1, 1970 there were 764 members, classified as follows: 514 individual members, 185 under family membership, 28 corresponding, 37 shell clubs, 7 Honorary Life Members, one Life President. Because of their geographical residence, 116 members are catalogued as well under the inactive Pacific Division.

During the 1969 meeting of the Executive Council, Secretary Teskey had indicated intent of resigning her office in 1970; this decision had been relayed to the 1970 Nominating Committee.

A membership drive had been launched in the Fall of 1969 and carried into 1970. Aimed at gaining institutional subscriptions and attracting publishing malacologists not now affiliated with the AMU, it had resulted at mid-year (1970) in a gain of about 100 over the normal average."

The report of the Secretary was accepted as read.

The 1969 report of Treasurer Baker was read:

Report of the Treasurer for the Fiscal Year ended Dec. 31, 1969.

Checking Account:		
Balance on hand, January 1, 1969		$1407.43
Receipts:		
Regular and Family Members	$1846.26	
Corresponding Members	93.40	
Shell Clubs	234.50	
Sales of HTCS	595.76	
Contributions of authors for printing	277.50	
Interest on 5% savings bonds ($3000)	150.92	
Sales, back issues of Bulletin	27.00	
1969 Meeting at Marinette, Wisc.	206.40	
Miscellaneous	1.80	
Total Receipts		3433.54
Total cash to be accounted for		4840.97
Disbursements:		
Printing & mailing 1968 Annual Report	$1957.49	
Other Printing	128.19	
Office Supplies, Sec. & Treas.	79.00	
Postage—Sec., Treas. & Publ. Ed.	347.95	
Bank Charges	34.07	
Total Disbursements		$2546.70

Balance in Checking Account, Dec. 31, 1969			**2294.27**
Total Cash Accounted for			**$4840.97**
Savings Account:			
Balance, January 1, 1969	**$634.45**		
4½% interest for year	**28.85**		
Total Savings, December 31, 1969		**$663.30**	
Recapitulation of Assets:			
Cash in Checking Account		**$2294.27**	
Savings Account		**663.30**	
3 $1000 5% Savings Bonds		**3000.00**	
Secretary's Petty Cash		**100.00**	
Treasurer's Petty Cash		**10.00**	
TOTAL ASSETS			**$6067.57**
Liabilities:			
Life Membership Fund			**1470.88**
NET WORTH, Unallocated Capital Fund			**$4596.69**
Increase over 1968	**$915.69**		

Treasurer's Note: **This increase shows up largely because there were no traveling expenses for either Secretary, Treasurer, or Pacific Division Secretary. Also the receipts from the sale of HOW TO COLLECT SHELLS were substantially higher than last year. Some of these receipts will at some future time be used to reprint HTCS or print other material and should not be regarded as a true profit.**

Respectfully submitted,
Bernadine B. Baker, Treasurer

The Treasurer's report was approved as read.

Action taken at the July 17th, 1970 meeting of the AMU Executive Council was read; Council had:

Approved appointment of Dr. Ralph Dexter to represent the AMU at AAAS meetings through 1972;

Instructed Vice-President David Stansbery to arrange transfer of the site of AMU incorporation from California to a State not requiring that an AMU officer be a permanent resident of that State;

Heard and given unanimous approval to the petition that Dr. Leo G. Hertlein be made an Honorary Life Member of the AMU;

Discussed, amended and approved as amended the proposed Constitutional revision prepared by Drs. Solem, Clarke and Rosewater;

Heard and given unanimous approval of the slate of nominated officers for 1970–71;

Instructed Publications Editor Jacobson that Newsletters #2 and #3 shall be issued over the next twelve months, that How to Collect Shells be revised when the present supply is exhausted, and that the Annual Report Bulletin shall continue in its present general pattern;

Accepted an invitation to hold the 1972 meeting in Galveston, Texas, authorized Vice-President Stansbery to select a meeting site and date for 1971;

Discussed the status of the presently inactive Pacific Division, concluded that future development lies in the hands of the governing body of that organization;

Adjourned.

This report was accepted as read.

Copies of the proposed revision of the AMU Constitution were made available; President Solem explained the additions, deletions and changes made by the Executive Council; following brief discussion from the floor the motion was made and carried that the Constitutional Revision as amended by the Council be given the unanimous approval of the members present. (Before adoption, it must receive a majority vote of approval by the Membership at Large.)

The Nominating Committee (Drs. Clarke, Dexter and Rosewater) had prepared the following slate: President, David H. Stansbery; Vice-President, Arthur S. Merrill; Secretary, Marian Hubbard; Treasurer, Mrs. H. B. Baker; Publications Editor, Morris Karl Jacobson; Councillors at Large, Kenneth Boss, Twila Bratcher, John Root, Anne B. Speers. A motion was made from the floor, seconded and carried that the Secretary be instructed to cast a unanimous ballot for the slate as read.

There being no further business, the 1970 AMU Business Meeting was adjourned.

NEWS, NOTICES, NOTES

The major part of the October 1970 edition of the Nautilus (volume 84, no. 2) is devoted to Leo George Hertlein who recently retired as Curator of Invertebrate Paleontology of the California Academy of Sciences. Dr. Hertlein was president of the AMU in 1967 and was elected an honorary life member by the Executive Council at Key West in 1970. Besides a short biographical sketch, the issue contains a list of the taxa proposed in honor of Dr. Hertlein by various authors, a bibliography of his works, and a complete list of all the new names introduced by him from 1925 to 1970.

* * *

A symposium during the 34th Annual Meeting of the AMU at Corpus Christi, Texas on July 16, 1968 presented several lectures by eminent malacologists surveying the marine, land, and freshwater molluscan faunas of North America for rare and endangered species. This was recently published in the journal MALACOLOGIA. By special arrangement, reprints of this symposium are available through the AMU. This landmark publication is an authoritative guide to those species in danger of extinction by man's activities. Nowhere else is this data available. It will be a standard reference for years and should be in the library of every conservationist as well as everyone specially interested in mollusks. Copies are $1.15 each and may be obtained from the secretary, Mrs. Marian S. Hubbard, 3957 Marlow Court, Seaford, New York 11783.

* * *

The 1971 meeting of the American Malacological Union will be July 15 through 19 at Coco Beach, Florida. Our hosts will be the Astronaut Trail Shell Club.

* * *

An explanation and an apology.

We regret that we are unable to run the topographic map identifying the members in attendance at the Key West meeting whose group photograph appears on page 82. There are so many persons in the picture—a reflection of the huge attendance which this meeting enjoyed—that the map details would have been too small for practical purposes. Moreover, in spite of all our efforts, too many faces remain unidentified.

IN MEMORIAM:

Mrs. Ward Brown
Joseph S. D'Amico
Joseph Golden
Dr. Fritz Haas
George F. Kline
Percy A. Morris
LeRoy Norton
Mildred M. Novak
P. (Rip) Teskey
Dr. d'Alte A. Welch
Dr. Malcolm L. MacLeod

ACTIVE MEMBERS

Aalund, Mrs. Susan, Railroad Ave., Roslyn, N. Y. 11576

Abbott, Dr. and Mrs. R. Tucker, Delaware Museum of Nat. Hist., Greenville, Del. 19807

Abel, Richard & Co., P.O. Box 4302, Portland, Oregon 97208

Adams, Lawson, 2100 S. Bay St., Milwaukee, Wisc. 53207. (Amateur.)

Aguayo, Dr. Carlos G., College of Agriculture, Mayagüez, Puerto Rico 00709

Albert, Mrs. Ernest, 905 Bayshore Blvd., Safety Harbor, Fla. 33572

Aldrich, Dr. Frederick A., Marine Sciences Research Lab., Memorial Univ., St. Johns, Newfoundland, Canada. (Decapod cephalopods.)

Alexander, Robt. C., 423 Warwick Rd., Wynnewood, Penn. 19096

Allen, Dr. J. Frances, 6000 42nd Ave., #311, Hyattsville, Md. 20781

Allen, Jas. E., 1108 Southampton Dr., Alexandria, La. 71301. (Tertiary micro-mollusca.)

Allen, Mrs. Lawrence K., Box 822, Port Isabel, Texas 78578. (*Murex*, *Pecten*, world marines.)

Allen, Miss Letha S., 187 Argyle St., Yarmouth, Nova Scotia, Canada. (Mollusks in general.)

Allen, Wm. H., Jr., 1101 Rudd Avenue, Auburn, Alabama 36830

Anders, Kirk W., Shells of the Sea, P.O. Box 1418, Ft. Lauderdale, Florida 33302

Anderson, Carleton J., Kettle Creek Rd., Weston, Conn. 06880

Anderson, Paul H. and Eugenia, 1912 Patterson Ave., Key West, Florida 33040

Angstadt, Mrs. Earle K., Longview Farm, 959 Whitner Rd., Reading, Pa. 19605

Arnold, Ben E., Rt. 5, Box 27, Port Orchard, Wash. 98366

Aslakson, Capt. and Mrs. Carl I., 5707 Wilson Lane, Bethesda, Md. 20034

Athearn, Herbert D., Rt. 5, Box 376, Cleveland, Tenn. 37311. (Freshwater mollusks.)

Athearn, Mrs. Roy C., 5105 N. Main St., Fall River, Mass. 02720. (Land shells.)

Auerbach, Stuart, 1710 Algonquin Trail, Maitland, Florida 32751

Avery, Mrs. Rada Gail, Box 3044, Riviera, Ariz. 86442. (Shells of N. America; exch.)

Baerreis, David A., 1233 Sweet Briar Road, Madison, Wis. 53705. (Paleoecological interpretation through mollusks.)

Baily, Dr. Joshua L., P.O. Box 1891, La Jolla, Calif. 92038

Baker, Dr. and Mrs. Horace B., 11 Chelten Rd., Havertown, Penn. 19083

Baker, John A., P.O. Box 4524, Patrick AFB, Florida 32925. (General interest.)

Baker, Nelson W., 279 Sherwood Dr., Santa Barbara, Calif. 93105. (General interest.)

Baker, Wilma, Orange Acres, Lot 65, Sarasota, Florida

Barlow, Dr. and Mrs. G. Barton, 5 Downey Drive, Tenafly, N. J. 07670

Barr, Mr. and Mrs. J. W. and J. W. Jr., 405 Prairie Street, St. Charles, Ill. 60174. (Cowries.)

Barton, James, 20 Newfield Dr., Rochester, N. Y. 14616. (General interest.)

Bates, John M., Dept. Biology, Eastern Michigan College, Ypsilanti, Mich. 48197

Baum, Newman N., 83 Weaving Lane, Wantagh, L. I., N. Y. 11793

Bayne, Dr. and Mrs. C. J., Museum of Zoology, University of Michigan, Ann Arbor, Mich. 48104. (Gastropod physiology.)

Bazata, Kenneth R., Univ. of Nebraska, Oldfather Hall 434, Lincoln, Nebraska 68508. (Terrestrial pulmonates.)

Becker, Mr. and Mrs. Albert F., 2157 Sunrise Dr., LaCrosse, Wis. 54602. (Mississippi River shells.)

Bedell, Adele Koto, 2643 Laundale Dr., Beloit, Wis. 53511

Bedford, Mrs. W. A., Jr., 633 S. Palm Avenue, Sarasota, Florida 33577. (Marine.)

Beetle, Mrs. Dorothy, Peninsular Junior Nature Museum, J. Clyde Morris Blvd., Newport News, Va. 23601. (Land and freshwater world shells.)

Behrens, Grace, 719 E. Madison Street, Lancaster, Penn. 17602. (Abalone, starfish.)

Bennett, Chas. G., 374 73rd Street, Ocean, Marathon, Florida 33050

Bennis, Sylvia A., 3412 N.W. First Street, Miami, Florida 33125

Bequaert, Dr. Joseph C., Dept. of Entomology, Univ. of Ariz., Tucson, Ariz. 85717

Berg, Mr. and Mrs. Fred, 214 So. Canada, Santa Barbara, Calif. 93103

Berry, Dr. and Mrs. Elmer G., 1336 Bird Rd., Ann Arbor, Mich. 48103

Berry, Dr. S. Stillman, 1145 W. Highland Ave., Redlands, Calif. 92373

Bertsch, Hans, Franciscan School of Theology, 1712 Euclid Ave., Berkeley, Calif. 94709. (Opisthobranchs: ecological relationships; life history; behavior; feeding; taxonomy.)

Bickel, David, Dept. Earth Sci., Minot State College, Minot, N. D. 58701. (Systematics and ecology of freshwater mollusks, esp. pleurocerid snails.)

Bijur, Jerome M., 135 7th Ave. N., Naples, Fla. 33940. (Buy, exch. Florida marine.)

Bingham, Frasier O., Inst. Marine Sciences, Box 40, 10 Rickenbacker Causeway, Miami, Florida 33149. (Gastropods: life histories.)

Bippus, Mr. and Mrs. Alvin C., 2743 Sagamore Rd., Toledo, Ohio 43606. (Marine gastropods.)

Bishop, Stephen H., 4039 Turnberry Circle, Houston, Texas 77025. (Metabolism.)

Blaine, Mr. and Mrs. Alger P., 237 19th Ave. S., St. Petersburg, Florida 33705. (Summer: 74 Palmer Ave., Springfield, Mass. 01108.)

Blair, J. F., 7006 W. 35th Street, Berwyn, Illinois 60402

Bleakney, Dr. J. Sherman, Dept. of Biology, Acadia Univ., Wolfville, Nova Scotia, Canada. (Nudibranchs and sacoglossans; ecology, zoogeography, systematics.)

Blum, Howard F., 2881 N. E. 22 Court, Pompano Beach, Florida 33062

Bonus, Mrs. Warren, 26432 Marine View Drive, Kent, Wash. 98031. (All shells.)

Boone, Mrs. Hollis Q., 3706 Rice Blvd., Houston, Texas 77005

Borkowski, Dr. and Mrs. Thos., 381-44-2275, U.S. Army Preventive Medicine Activity (PI-WOZL-AA), APO San Francisco, Calif. 96331. (Systematics, ecology of Littorinidae; also micro-mollusks.)

Born, Mrs. Thomas, 4345 Manolete, Pensacola, Florida 32504

Boss, Dr. Kenneth Jay, Museum of Comparative Zoology, Cambridge, Mass. 02138

Bottimer, L. J., St. Francis Village, Crowley, Texas 76036. (Recent & fossil mollusks.)

Boyd, Dr. and Mrs. Eugene S., 6806 Gillis Road, Victor, N. Y. 14564. (All aspects.)

Bradley, J. Chester, 604 Highland Rd., Ithaca, N. Y. 14850

Bradley, John C., 469 Farmington Ave., Waterbury, Conn. 06710. (Travel and collect.)

Bratcher, Twila L., 8121 Mulholland Terr., Hollywood, Calif. 90046

Bright, Mr. and Mrs. Jos. C., 30 West Chestnut Hill Ave., Philadelphia, Penn. 19118. (Marine gastropods.)

Brooks, Mr. and Mrs. John C., 3050 Sunrise Blvd., Ft. Pierce, Florida 33450

Brown, Dorothy, 7090 Madera Drive, Goleta, Calif. 93017. (Pectens.)

Brown, Dr. and Mrs. Harvey E., 9455 S.W. 81st Ave., Miami, Florida 33156

Brown, Wade G., 1317 Arnette Ave., Durham, N. C. 27707

Broyles, Dr. and Mrs. Ralph E., 5701 Fairfield Dr., Ft. Wayne, Ind. 46807

Brunson, Dr. Royal Bruce, Montana State Univ., Missoula, Mont. 59801

Budnick, Roger A., 9722 Robinson Ave., Cleveland, Ohio 44125

Buffalo Museum of Science, Research Library, Humboldt Parkway, Buffalo, N. Y. 14075

Bullis, Harvey, Jr., 3804 Moore Pl., Alexandria, Va. 22305

Burch, Dr. John B., Museum of Zool., Univ. of Mich., Ann Arbor, Mich. 48104. (Land and freshwater mollusks.)

Burch, Mr. and Mrs. John Q., 1300 Mayfield Rd., Apt. 61-L, Seal Beach, Calif. 90740

Burch, Dr. and Mrs. Thomas, Hawaii. (Dredging.)

Bureau of Commercial Fisheries, Biological Laboratory, Oxford, Md. 21654

Burgers, Dr. and Mrs. J. M., 4622 Knox Rd., Apt. 7, College Park, Md. 20740

Burggraf, Margaret R., 608 N.W. 26th Street, Ft. Lauderdale, Florida 33311. (Self-collected Florida shells.)

Burghardt, Mr. and Mrs. Glenn, 14453 Nassau Road, San Leandro, Calif. 94577

Burke, Alice L. and Thos. D., Jr., 1820 S. Austin Blvd., Cicero, Ill. 60650. (Marine mollusks of eastern U. S. A.)

Caffin, John, 528 W. New York Ave., DeLand, Fla. 32720. (World shells.)

California Institute of Technology, Millikan Library, Pasadena, Calif. 91109

Campbell, Edw. D., UDT THIRTEEN, NAB, Coronado, San Diego, Calif. 92155

Cardeza, Carlos M., P.O. Box 6746, Houston, Texas 77005. (Summers: Rt. 1, Box 104, Sanibel, Florida 33957.) (Florida and Texas shells.)

Cardin, Glenn Wm., 7491 Valaria Dr., Highland, Cal. 92346

Carley, T. S., 407 Kingston, Deerfield, Ill. 60015

Carlton, Jas. T., Dept. Invert. Zool., Calif. Academy of Sciences, San Francisco, Calif. 94118. (Estuarine & brackish water mollusks.)

Carney, W. Patrick, Naval Medical Center, Naval Medical Research Inst., Bethesda, Md. 20014

Carr, Mrs. Jack C., 912 Broadway, Normal, Ill. 61761. (*Cypraea*; *Murex*.)

Carriker, Dr. M. R., Marine Biological Lab., Woods Hole, Mass. 02543. (Shell demineralization; boring mechanisms of mollusks; marine ecology.)

Carroll, Bonnie L., 106 Gettysburg Rd., San Antonio, Texas 78228. (Collecting, trading.)

Castagna, Michael, Va. Inst. Marine Sci., Wachapreague, Va. 23480. (Pelecypod larval behavior.)

Cate, Mr. and Mrs. Crawford N., 12719 San Vicente Blvd., Los Angeles, Calif. 90049. (*Mitra*, *Cypraea*; no exchanges.)

Chace, Emery, 24205 Eshelman Ave., Lomita, Calif. 90717

Chandler, Carl and Doris, P.O. Box 621, Rt. 28, Chatham, Mass. 02633. (Winters: P.O. Box 2344, Ft. Myers Beach, Florida 33931.) (Cones, Cypraea.)

Chanley, Paul, 502 Colony Street, Melbourne Beach, Florida 32951

Chichester, Lyle F., Dept. Biol. Sci., Central Conn. State College, New Britain, Conn. 06050. (Ecology of terrestrial gastropods, biology of land slugs.)

Christensen, Carl C., 1612 Kamole Street, Honolulu, Hawaii 96821

Christensen, Mary Lee, 727 San Fernando Court, San Diego, Calif. 92109

Clark, John W., Jr., 1407 Westmoor, Austin, Texas. (Economic exploitation of mollusks by prehistoric Indians, their use in ecological reconstruction.)

Clark, Wm. F., Mark D. and Robert G., 504 Valley Rd., Terre Haute, Ind. 47803

Clarke, Dr. and Mrs. Arthur H., Jr., Dept. of Mollusks, Nat'l Museum of Canada, Ottawa, Ontario, Canada

Clarke, Dr. Rosemary, P.O. Box 615, Dubuque, Iowa 52001

Class, Harry E., 35 Tyrell Street, Simcoe, Ont., Canada

Clench, Dr. Wm. J., 26 Rowena Street, Dorchester, Mass. 02124

Cleveland Museum of Nat. Hist., 10600 E. Blvd., Cleveland, Ohio 44106

Clover, Phillip W., Box 33, Div. 32, FPO, New York 09540. (*Marginella, Mitra, Voluta, Conus, Cypraea.*)

Coan, Dr. Eugene, 891 San Jude Ave., Palo Alto, Calif. 94306

Cole, Mr. and Mrs. Jos. H., Jr., 255 El Pueblo Way, Palm Beach, Florida 33480 (Florida and Caribbean marine shells.)

Colton, Harold S., P.O. Box 699, Flagstaff, Ariz. 86001. (Land snails of Northern Arizona; ecology.)

Compitello, Mrs. Juliette, 399 St. John's Place, Brooklyn, N. Y. 11238

Conde, Vincent, Redpath Museum, McGill Univ., Montreal, Quebec, Canada

Conway, Miss Leslie E., 70 Stoneyside Lane, Olivette, Mo. 63132

Conway, Mrs. Richard, 1350 Oakland Rd., #35, San Jose, Calif. 95112

Coomler, Bob, 974 Concha Loma Dr., #2, Carpinteria, Calif. 93013

Cooper, J. W., 2300 Club Lane, Little Rock, Ark. 72207

Cooper, Robt. W. and Marjorie, 5012 Pfeiffer Rd., Peoria, Ill. 61607. (Florida marine shells; world *Murex, Pecten, Spondylus.*)

Coplantz, Mrs. Karen, 1534 Olsen Dr., Gustine, Calif. 95322

Corbett, Wm. Phelps, 2939 Nelson St., Ft. Myers, Florida 33901. (Exch. rare *Cypraea, Olivia, Murex.*)

Corey, Mrs. David S. K., 916 Airport Rd., Blacksburg, Va. 24060

Corgan, James X., Dept. Geography and Geology, Austin Peay State Univ., Clarksville, Tenn. 37040. (Microscopic gastropods.)

Cornell University, Albert R. Mann Library, Ithaca, N. Y. 14850

Cox, Lee E., 9 Langholm Drive, Nashua, N. H. 03060

Craig, Mrs. G. E. G., Apdo. Postal 448, Guaymas, Sonora, Mexico

Craine, Mrs. Ruth A., Box 652, Sherburne, N. Y. 13460

Cramer, Frances L., 766 Obispo Ave., Long Beach, Calif. 90804. (Ecology; conservation.)

Cramer, Mrs. Janet R., Box 187, Philipsburg, Sint Maarten, Netherlands Antilles

Crittenden, Mrs. John S., 624 Waterfall Isle, Alameda, Calif. 94501

Cull, Mrs. Robt. R., 7927 Chippewa Rd., Brecksville, Ohio 44141

Cummings, Raymond W., 37 Lynacres Blvd., Fayetteville, N. Y. 13066. (Shells of the West Indies, esp. Windward and Grenadine.)

Cutler, Henry H., 105 Abbott Rd., Wellesley Hills, Mass. 01570

Cvancara, Dr. Alan Milton, Dept. Geology, U. of N. Dak., Grand Forks, N. Dak. (Recent freshwater mussels and Early Tertiary mollusks.)

Danforth, Louise L., 729 Indian Beach Lane, Sarasota, Florida 33580

D'Attilio, Mr. and Mrs. A., 4124 47th St., San Diego, Cal. 92105

Davis, Derek S., Nova Scotia Museum, Halifax, Nova Scotia, Canada. (Gastropod biology and taxonomy.)

Davis, Dr. George M., Dept. Mollusks, Academy of Nat. Sci., Philadelphia, Penn. 19103

Davis, John D., 26 Norfolk Avenue, Northampton, Mass. 01060. (Ecology of Marine bivalves.)

Dawley, Dr. Charlotte, 114 So. Mendenhall St., Greensboro, N. C. 27403
Deane, Richard L. and Nancy L., 6101 Grimes Court, Norfolk, Va. 23518
Deatrick, Paul A., 218 S.W. 32 Ave., Miami, Florida 33135. (*Strombus, Busycon.*)
DeGaetano, Jean Gilliam, 53 Pennsylvania Ave., Montvale, N. J. 07645. (Collect and buy marine shells.)
DeLuca, Mrs. John A., Miss Gladys, Deborah Rd., Hanover, Mass. 02339
Demond, Joan, Dept. Geology, Univ. of Calif., Los Angeles, Calif. 90024
Desmond, Hon. Thos., 94 Broadway, Newburgh, N. Y. 12550
Dexter, Dr. and Mrs. Ralph W., Dept. Biol. Sci., Kent State Univ., Kent, Ohio 44240
Dietrich, Mr. and Mrs. Louise E., 308 Veri Drive, Pittsburgh, Penn. 15220
Dixon, Mrs. Ruth S., 711 Parker St., Durham, N. C. 27701. (Marine mollusks.)
Doucet, Mrs. P., Bay # 24, 3313 Dewdney Trunk Rd., Port Moody, B.C., Canada
DuBar, Dr. and Mrs. Jules R., Geoscience Dept., Morehead State Univ., Morehead, Ky. 40351. (Cenozoic and recent mollusks—ecology and paleoecology.)
Duch, Thos. M., Dept. Science, Bennett College, Millbrook, N. Y. (Reotaxic behavior, embryology.)
Dundee, Dr. Dolores S., Dept. Biol., La. State Univ. in New Orleans, New Orleans, La. 70150. (Land mollusks; freshwater mussels.)
Dunn, V. Roger, 4727 27th Ave., So., Gulfport, Florida 33711
Dvorak, Stanley J., 3856 W. 26th St., Chicago, Ill. 60623. (Muricidae.)

Eddison, Grace G., M.D., 810 Soundview Dr., Mamoroneck, N. Y. 10543. (World marine.)
Edmiston, Mrs. J. R., 5038 Hazeltine Ave., Apt. 301, Sherman Oaks, Calif. 91403
Edwards, D. Craig, Dept. Zoology, Univ. of Massachusetts, Amherst, Mass. 01002. (Population ecology & behavior of marine benthic molluscs.)
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Symposium on Commercial Marine Mollusks of the United States

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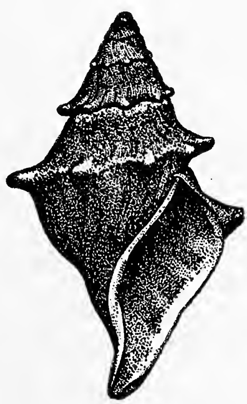

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SYMPOSIUM ON COMMERCIAL MARINE MOLLUSKS OF THE UNITED STATES

ARTHUR S. MERRILL, CONVENER

INTRODUCTION

The American Malacological Union has traditionally been concerned with the taxonomy, ecology, general biology, and conservation of the mollusks of the United States and elsewhere. This symposium was convened to explore the commercial aspects of our molluscan fauna, and to describe in detail the species and techniques involved in fisheries for this significant sector of our living aquatic resources. The symposium also defined those critical problems, particularly disease and pollution, that limit shellfish production.

In any review of this type, it soon becomes obvious that one of the weak points in the assessment of world fisheries is the lack of intensive fishery monitoring procedures. It is certainly not coincidental that generally the leading fishery nations are those that undertake monitor programs and that base fisheries management on these data. Assessment studies are particularly relevant in molluscan fisheries, since the animals are mostly sessile and more accurate population data can be acquired than for highly mobile finfish species.

Commercial mollusks are the most important group of invertebrates in world fisheries. In the 10-year period 1958–68, the world catch increased by 50% and this dramatic expansion of molluscan fisheries promises to continue. According to figures published by the Food and Agriculture Organization (FAO), production of mollusks in 1967, the latest year for which full statistics are available, amounted to 3.12 million metric tons by live weight (see Table I). Thus, the total weight of mollusks was more than double the nearest invertebrate competitor, the crustaceans.

Oysters are perennially the leaders in the molluscan fisheries, and a catch of 839 thousand metric tons was recorded for 1967. The United States accounts for almost half of the catch according to the FAO statistics in table I. However, since FAO bases its figures on live weight, or the weight of the animal *and* its shell, the figures do not give a true picture of the actual edible catch. Using other sources, we find that the Bureau of Commercial Fisheries Statistical Digest reports landings of 60 million pounds of oyster meats for 1967, while Fujiya (1970) gives the oyster production of Japan in 1967 as 45 thousand metric tons of shucked meats, or 99 million pounds. This difference in the live weight and shucked meat figures reflects a difference in fishery practices of the two countries. It appears that Japan, with its off-bottom methods of oyster culture, is harvesting a product which has a thinner shell than the wild or natural bar oyster of the United States. This discrepancy does not enter into the figuring of production of other shellfish, with the possible exception of the scallop.

Japan and the United States have competed not only for eminence in oyster production but generally for top rank in the molluscan fisheries. Japan is the dominant country for both squid (no. 2 in world shellfisheries tonnage) and for octopus (no. 5). The Japanese catch of squid, 83% of the

Table I. World Molluscan Shellfish Catch—1967
Arranged According to Production, with Dominant Country and Catch*
(in Metric Tons Live Weight**)

Species	Total Catch	Dominant Country	Catch	%
Oyster (Ostreidae)	839,000	United States	415,000	49
Squid (Loliginidae, Ommastrephidae)	697,000	Japan	581,100	83
Clam (Veneridae, Solenidae, Myacidae, Mactridae)	417,000	United States	184,500	44
Mussel (Mytilidae)	273,000	Netherlands	85,600	31
Octopus (*Octopus* spp., *Eledone* spp.)	181,000	Japan	98,200	54
Scallop (Pectinidae)	134,000	United States	54,900	41
Cockle (Cardiidae)	74,000	Malaysia	26,900	36
Cuttlefish (*Sepia* spp., *Sepiola* spp.)	60,000	Spain	16,900	28
Freshwater Clam (*Corbicula* spp., Unionidae)	55,000	Japan	42,000	76
Arkshell (Arcidae)	29,000	Malaysia	26,900	93
Abalone (Haliotidae)	20,000	Mexico	6,400	32
Conch, Whelk, Top-Shell, etc. (Strombidae, Buccinidae, *Busycon* spp., Trochidae, etc.)	19,000	Japan	7,200	38
Winkle (Littorinidae)	4,000	Ireland	2,000	50
TOTAL WORLD CATCH (including miscellaneous mollusks not mentioned above)	3,120,000			

* Source: FAO—1969 Yearbook of Fishery Statistics, Catches and Landings—1968, Vol. 26: 318 p.

** Live Weight = weight of shell and animal

world total, amounting to 581,100 metric tons, is the largest molluscan fishery reported in 1967 for a single country.

In 1967 the United States was the chief producer of clams by a slight margin, but statistics show that Japan has been a close competitor here also and has on occasion exceeded U. S. production. However, the U. S. clam industry is thought to have a great potential, especially in the opening up of ocean quahog and razor clam beds and exploitation of fisheries for *Rangia* and the sunray clam. The 1967 fishery was based almost totally on the hard, soft, and surf clams. The United States and Canada account for most of the scallops taken; this fishery is not only no. 6 in the world list, but also one of the more valuable. The growing fishery for the calico scallop of the southeastern Atlantic coast has contributed to increased landings and value.

The Netherlands excels in the production of mussels, but other European countries and Chile also have large mussel fisheries. Spain was the top country for cuttlefish, leading Japan by only a slight margin. Malaysia has the largest fishery for cockles and accounts for nearly all of the total catch of arkshells. The Mexican fishery for abalones slightly exceeds Japan's, but

Japan again is tops in the fishery for conchs and whelks. The fishery for winkles is largely confined to the British Isles, where Ireland produces 50% of the world catch.

A review of world fisheries, then, shows that Japan is far and away the dominant country in shellfisheries. Leading in the production of oyster meats, squid, octopus, and conchs; almost equaling the production of the dominant country in the case of clams, cuttlefish, and abalone; leading as well in the fishery for the freshwater clam—the superior position of Japan cannot be denied. The United States follows with second place in importance, but its major fisheries are both large and impressive. Even more impressive is the potential estimated for developing new fisheries and increased exploitation of molluscan resources that are now underutilized.

The following contributions summarize individual presentations at the 36th meeting of the AMU at Key West, Fla., on July 17, 1970. The participants are authorities in the various fields of commercial mollusk interests. The symposium as a whole describes the past history and the current status of our molluscan fisheries, and offers some forecasts on the part they may play in meeting future protein requirements. The convener has taken the liberty to write this introduction and the summary following the contributions.

A MONTAGE OF OYSTER CULTURE FROM PAST TO FUTURE[1]

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Oysters are the most prolific and tolerant of mollusk species and a vast array of predators and diseases did not prevent the formation of natural reefs or beds. Oyster communities, the first recognized ecosystems (Möbius), thrived until man intervened—beginning with the Romans in Britain and threatening to end with industrialized man's monstrous reef-devouring suction dredges in the Gulf of Mexico and the Chesapeake Bay. The famous natural public beds of France were depleted over a century ago and private culture was adopted. On the East Coast of North America low salinities resulting from spring flows of large rivers such as the Mississippi, Susquehanna, Potomac and Delaware, provide sanctuaries where breeding stocks survive in the near absence of predators, diseases and most competitors, and despite overfishing by man. These sanctuaries are now threatened by storage, diversion and pollution of water to satisfy rapidly increasing demands for water and power.

The oyster fisheries of the world are almost completely dependent upon natural sets of "wild" oysters. "Free" fisheries on public beds on the East Coast are enmeshed in a set of traditions and limitations, enshrined with the magic word conservation, that insures inefficiency of harvest and use. Antiquated gears (tongs and tooth dredges) persist in all areas except New England although hydraulic dredges are available and utilized in clam fisheries (*Mya, Mercenaria, Spisula*). Seed oysters are produced cheaply, on public beds mostly, but misuse in time and place of transplanting is prevalent.

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[1] Contribution no. 373, Virginia Institute of Marine Science.

Oysters have become a luxury food in most regions of the world and producers depend upon scarcity and high prices rather than productivity for profits. Recent mid-Atlantic coast losses to a protozoan disease, caused by *Minchinia nelsoni* and called MSX, have accentuated the problem. Oystermen located in low-salinity areas free of MSX have made generous profits in the 1960's whereas their neighbors in high salinities were forced out of business. Setting failed in the James River that had supplied most seed oysters for private grounds in Chesapeake Bay for nearly a century. Production from James River dropped to one-fifth the level sustained in the 1950's and seed production declined from over 2,000,000 bushels annually to 264,000 in 1969–1970. Chesapeake Bay, Maryland with its low salinity areas has increased production in the last three years and Louisiana also provides big crops between hurricanes. Yet the price of landed fresh-shucked oysters has dropped to $3 to $4 a bushel, similar to that prevailing before the mid-Atlantic catastrophe. Retail prices remain high and consumption has contracted severely in ten years.

The most encouraging new developments have come out of New England and the Pacific coast. Certain generalizations may be made regarding oyster biology with change of climate from north to south along the East Coast. Spatfall or setting is usually deficient north of Chesapeake Bay and excessive south of it. Growth is slow in the north, requiring four to six years to market oysters, whereas 18 months is adequate in the Gulf of Mexico. Predators and diseases tend to increase in variety and severity from north to south.

Oysters grown in Long Island Sound and north are all sold for half-shell stock at prices of $16 to over $20 per bushel. This has permitted considerably more effort in rearing oysters and protecting them. Several hatcheries are producing spat with centrifuged natural water. Grounds are treated for predators by spreading quick lime on starfish and polystream-treated sand (heavy oils) and Sevin to kill drilling snails. Also seed beds are prepared by vacuum cleaner-like suction dredges. Beds are monitored for predators and other problems by SCUBA divers and starfish mop patrols.

A recent discovery by a private hatchery at Pigeon Point, California, of a method for producing cultchless or free spat has stimulated adoption of almost as many similar methods as there are hatcheries. Patents for ground oyster shell, rubber-covered automobile tire beads, and a variety of other cultches have been sought or obtained. Most of these efforts are aimed at increasing spatfall and quality by getting cultch off the bottom and producing single well-shaped oysters for machine shucking (not yet fully attained). West Coast producers, emulating the Japanese, have produced significant quantities of Pacific oyster seed on shell strings in favorable setting areas (Dabob Bay and Pendrell Sound are examples).

Control of oyster fisheries is necessary to permit mechanization, improve quality and increase production. The easiest area for manipulation and quality control is in seed production. Despite emphasis on artificial cultch and cultchless spat, natural sets make hatchery operations seem insignificant. A light set of 100 to 200 spat per bushel in the Potomac River in 1963 provided five years of excellent oyster production. Cultch was scarce and this level of seed count is considered inadequate for public or private transplant-

ing. Similar spatfalls have occurred in Long Island Sound recently, with dramatic changes in the prospects for the industry. However, a very large percentage (often 90% or more) of seed oysters is wasted or lost by predation, smothering, and mishandling.

Much effort has been spent attempting to adapt the Japanese float and long-line methods of oyster culture. Intensive three-dimensional culture is practical in tidal waters if problems of cost, fouling, and rapid turnover of crops can be solved. In tidal waters extremely dense populations of shellfish may be grown on shell strings or racks of trays. Ponds have rarely been used successfully, for the controlled conditions expected usually are compromised by new problems. Shallow wind-exposed waters and lack of tidal exposure which would help to limit fouling and predators have kept suspension culture from being feasible on the East Coast.

Perhaps the most common mistake is to assume that methods successful in one area or river can be adopted in others. Estuarine ecosystems occur in endless variety. In Long Island, cultchless spat are planted on prepared bottoms at sizes of about ½ inch. In Virginia, blue crabs feast on free oysters less than two inches in length. In 1963, Virginia began dredging buried reef shell, part of which was planted in seed areas as cultch. Five years later the operations ceased with shell reserves apparently depleted except for viable oyster beds. Maryland has planted dredged shells for ten years and appears to have a very large reserve supply. Under the protection of low salinities, Maryland is operating a public fishery that leads the nation in production. Seed production and restrictions on gear are the major limitations on production. It is interesting to speculate what would be done with the oysters that could be produced on now barren bottoms, if private management were allowed to rent and cultivate these thousands of acres of natural oyster grounds.

THE HARD CLAM AND SOFT CLAM OF THE WESTERN ATLANTIC COAST

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This paper describes uses of these clams by Indians, the present fishery, and certain aspects of the ecology of the shellfish.

Indian Uses. The hard clam or quahaug (*Mercenaria mercenaria* and *M. campechiensis*) and the soft-shell clam or manninose (*Mya arenaria*) were prominent in Indian culture as foods and artifacts. Quahaug valves were broken and the pieces ground into cylindrical beads which were strung for trade purposes. In this shell-money or wampum the dark, purple-colored beads were worth twice as much as the white ones. Sections of the crenulated shell margin, when pressed against the moist clay, formed decorative designs on pottery.

Present Fishery. Hard clam production averaged 14.3 millions of pounds of meats per year during the ten-year period 1959–1968. New York, the top

producer, averaged 5.4; New Jersey 2.1; Rhode Island 2.1; Virginia 1.9, and Massachusetts 1.4 million pounds. All others totalled 1.4 with no one state exceeding 0.4. The soft clam fishery, centered in northern New England and Chesapeake Bay, averaged 9.7 millions of pounds of meats a year, 1959–1968. Top producer, Maryland, averaged 6.3, followed by Maine (2.3) and Massachusetts (0.9). Intertidal populations of these clams provide a popular sport fishery in some states.

Soft clams, largely intertidal in the north, are dug by a "hoe,"—a short-handled rake with four broad-bladed tines. In Chesapeake Bay, nearly the entire resource is subtidal and it is harvested by a hydraulic escalator dredge. The hard-shelled clam can be harvested by rougher methods. Hand gear include the "hoe," basket-like scratch rake, bull rake, and tongs. Several types of mechanical gear are used; the dredges commonly are operated hydraulically and utilize water jets to free the clams from the substrate. The hydraulic escalator dredge is the most efficient gear; clams, jetted from the substrate, pass over a horizontal blade of the dredge onto a conveyor belt which brings them up to a tumbling cage from which smaller material drops back to sea before the dredged material is tumbled onto another moving belt for sorting.

Aquaculture of the hard clam is receiving much attention.

Ecological Considerations. Both hard and soft clams live in similar estuarine habitats, sometimes coexisting but not with each in abundance. Their ecology, not fully understood, is obviously somewhat different. Latitudinal distribution is distinct: the soft clam ranges from the Canadian Maritimes to North Carolina; *M. mercenaria* (the northern quahaug) is found principally in the northern portion of the hard clam distribution, from Maine southward, and *M. campechiensis* (southern quahaug), which has commercially-harvested offshore (oceanic) populations, mainly southward, New Jersey into the Gulf of Mexico.

Bivalves characteristically spawn during early summer when the increasing water temperature reaches a spawning-stimulating "threshold" level. After high summer temperatures, spawning may occur again in the autumn as the decreasing temperature passes a "threshold" level.

In laboratory crosses, the two *Mercenaria* species form viable hybrids; their early developmental stages are identical. Spawning can be induced easily in conditioned *Mercenaria,* but not in *Mya.* The early life stages of most bivalve mollusks are similar; only those of *Mercenaria* are described here. Eggs and sperm are discharged into the water. Unlike most bivalves, the eggs of the hard clam have a thick gelatinous envelope. Within 2 hours after fertilization, depending upon water temperature, the 2-celled stage is reached. Other factors such as food, turbidity, and salinity also affect the rate of development. In about 12 hours at room temperature, the microscopic, ciliated trochophore larva emerges from the gelatinous egg capsule. Soon thereafter shell secretion begins and a straight-hinged, shelled larva is formed. As this veliger enlarges, its shell begins to change shape and the umbone stage is reached. All of these stages are planktonic. The next stage is transitional, capable of swimming and of creeping over substrate, attaining an ultimate size which varies considerably, but metamorphosis to the next stage is most common at sizes from 200 to 215 microns in shell length. A true benthic stage results; in metamorphosis the swimming organ (velum) is lost and a

byssus gland becomes active. Byssus production stops at the juvenile stage, when the small clam is about 9 mm. in length.

Growth is step-wise—rapid shell formation with a slower increase in the soft parts. The mantle secretes shell material over its entire surface, creating a laminated structure in which the largest increments of deposition are around the periphery of the shell. This laminated structure must be studied in three dimensions to be fully appreciated. For example, a prominent growth "ring" on the surface of the shell is associated, internally, with a prominent layer of translucent material throughout the entire shell. It marks a time of abrupt cessation of shell formation. This readily visible record results from all-winter hibernation as well as short-term disturbances such as a heavy storm. Normal "biological clock" rhythms probably also are well-recorded in the shell but the magnitude of their record is microscopic and, thus far, inadequately studied. Even so, the sophisticated oxygen-isotope technique enables researchers to determine the water temperature at the time the shell material was deposited—even in fossil shells.

Clams are active burrowers, especially in the younger stages. The shell, water jets, and the synergistic-antagonistic relationships among the hinge, muscles, and hemocoel all play a role in burrowing. It is said that General George McClellan developed the water jet as an aid to sinking piling in sand after having observed clams.

Hard clams have the unique ability to rid themselves of mud even when out of water; a special mucus-secreting area of the mantle enables them to drivel.

The largest reported hard clams reveal the great species difference in shell weight: *M. mercenaria,* 6⅛ inches in length, 2.5 pounds live weight; *M. campechiensis,* 6⅝ inches, 6.5 pounds.

Anomalies in shell shape and soft parts are occasionally reported. Of interest are the asymmetrical shell deviation in *Mercenaria* which is suggestive of the *Exogyra* shape (one deeply cupped valve and the other nearly flat) and a bifurcated intake siphon which apparently may be formed in any species with well-formed siphons.

MINOR SPECIES—BAY SCALLOPS, RAZOR CLAMS, AND MUSSELS

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Three species of commercially valuable bivalve mollusks are presently of minor economic importance on the east coast of the United States.

The bay scallop, *Argopecten irradians,* once supported a fishery surpassed only by oysters and hard clams. Ecological problems (pollution and eel grass disease) have reduced the resource, while economic problems (market competition with other scallop species and unreliable supply) have depressed

the fishery. However, interest in bay scallops has been maintained by State and local agencies so that efforts to improve natural populations are underway and cultural practices are being developed. Intensive management may be instrumental in restoring some of the fishery, but it is doubtful whether the problems of coastal pollution and market competition can be overcome.

Razor clams, *Ensis directus*, are abundant over much of the east coast. The need for efficient catching gear and consumer education are limiting factors that will continue to discourage commercial exploitation. An existing sport fishery for razor clams should be promoted and could provide significant economic and recreational benefits for coastal communities.

The blue or edible mussel, *Mytilus edulis*, possibly holds the greatest promise for an expanded fishery on natural beds and for development of intensive aquacultural production. Rapid growth, byssal attachment, and ease of harvest are desirable attributes. Meat production per unit area is the highest recorded for any commercial animal and a superior meat-to-weight ratio, double or triple that of other commercial mollusks, makes it attractive for industrial processing. Although highly valued in Europe, the mussel has never been widely accepted in the United States. A sizable canning industry was developed during World War II, but disappeared with the relaxation of wartime restrictions. Cultural practices have been highly developed in Europe, notably raft culture in Spain, and this success has influenced other regions throughout the world to attempt mussel culture. The vast mussel resource of our east coast should be exploited and the mussel is recommended for those interested in molluscan aquaculture. The lack of acceptance for mussel meat by the American public should not be limiting since processed specialty products were successful in the past and new products, such as mussel protein concentrate, offer outstanding opportunities for expansion of the fishery.

WEST COAST MOLLUSK FISHERIES[1]

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The overall commercial mollusk fisheries of the Pacific Coast, though minor in comparison to those of the Atlantic Coast or Gulf of Mexico, are substantial and in certain localities are among the leading sources of income. The sports fishery for west coast species, particularly of clams, is far more intensive than in other parts of the United States. The estimated numbers of sports fishermen digging razor clams, for example, frequently exceeds the creditability of persons unfamiliar with the crowds appearing on a Washington beach during an extremely low tide.

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[1] Contribution No. 313 from the National Marine Fisheries Service Biological Laboratory, Galveston, Texas 77550.

When the first white men settled on the West Coast, extensive beds of native oysters, *Ostrea lurida*, were present from San Francisco Bay through most of British Columbia. The greatest natural abundance was in Willapa Bay and southern Puget Sound in the present State of Washington (Gunter and McKee, 1960). Natural reefs were quickly exploited, beginning in San Francisco Bay during the gold rush of 1849, in Willapa Bay in 1851 (Esveldt, 1948), and in British Columbia in 1884 (Quayle, 1969). In Willapa Bay, the industry peaked in the 1870's, quickly declined in the 1880's, and was abandoned between 1895 and 1906 (Esveldt, 1948). During the latter period, when oystermen in Willapa Bay began importing the eastern oyster (*Crassostrea virginica*), southern Puget Sound continued as an important producer of native oysters. Because of excessive mortalities of eastern oysters, importations of Pacific or Japanese oysters, *C. gigas*, began in 1922. Culture of this species became widespread along the Pacific Coast, relying almost entirely on seed imported from Japan. The State of Washington is the leading Pacific Coast producer, with peak production around 10 million pounds, and averages of about 8 to 9 million pounds over the past 10 years.

Although about 500 species of bivalve mollusks are native to the Pacific Coast, of which 35 are edible, only 9 appear in the commercial market. Most are too small or too infrequently found, or both, to support a commercial clam fishery (Amos, 1966). As Amos points out, the commercial harvest of clams along the Pacific Coast in 1963 was about 5½ million pounds, worth about a half million dollars to the fisherman. The razor clam (*Siliqua patula*), Pismo clam (*Tivela stultorum*), and bean clam (*Donax gouldi*) inhabit the sandy beaches of the open coast, while other species are found in the quiet waters of protected bays and sounds.

By far the most important clam on the Pacific Coast is the razor clam, *S. patula*. Although its range extends from Pismo Beach, California, to the Bering Sea, it occurs in commercial quantities only from Oregon to Alaska. The U. S. catch in 1963 comprised 48 percent of the U. S. Pacific Coast clam fishery and was worth $167,000 to the fishermen. Razor clams are eagerly sought by sportsmen; the Washington effort for the 1967 season (a poor year for clam abundance) totalled 750,000 digger trips. This probably represented a record high for numbers of diggers, but despite an increase of nearly 70,000 diggers (Tegelberg, 1967) the estimated total catch was at about the same level as in 1966 (11.5 million clams).

Although two species of *Saxidomus* — *S. nuttali*, and *S. giganteus* — are recorded, *S. giganteus* from Washington makes up about 99 percent of the U. S. commercial catch for butter clams. In 1963, the U. S. commercial catch totalled 51,000 pounds of meat worth $11,700, while British Columbia produced 684,200 pounds. Alaska contains large numbers of butter clams, but has no viable fishery because of problems with paralytic shellfish poison, harvesting, and processing.

The only remaining commercially important clam fishery is that for the littleneck clam. Actually, two species, one native and one immigrant, are involved. The native littleneck, *Protothaca staminea*, ranges from Alaska to Mexico, but is of commercial importance only in British Columbia and Washington (Amos, 1966). The U. S. catch in 1963 totalled 214,400 pounds of meats worth $107,194, while the British Columbia catch was 32,700 pounds

of meats. The Manila clam, *Tapes philippinarum*, was probably accidentally introduced from Japan long with *C. gigas* seed shipments and is now found from northern California to British Columbia. It competes with *P. staminea* in abundance in many areas, with 32,600 pounds being taken in British Columbia and 119,600 pounds, worth $62,756, in Washington in 1963.

All the above-mentioned clams, as well as numerous other species, are enthusiastically dug by sportsmen. Two species not taken commercially warrant mention. The Pismo clam, *T. stultorum*, from California was once so abundant that it was dug by horse-drawn plows for hog food. Because of overexploitation, the State of California now allows only recreational harvest under strict regulation. The geoduck, *Panope generosa*, is the largest of the Pacific Coast clams, reaching a weight of about 8 pounds, though larger specimens have been recorded. Geoducks are difficult to capture because they are usually buried 3 or more feet beneath the surface. They have traditionally been utilized only by sportsmen, but the State of Washington is considering permits for deep-water commercial harvest with hydraulic dredges.

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THE WORLD CULTURE OF MARINE MOLLUSKS[1]

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Commercial culture techniques for mollusks are relatively primitive when compared to land agriculture. Land agriculture has advanced to a state of complete husbandry of genetically improved stocks, whereas molluscan culture has remained in the more primitive states of wild harvest, wild harvest with control of catch and, at best, only partial husbandry. Obviously, there are fundamental factors producing such a discrepancy.

The answer may be found by drawing a parallel between conditions necessary for species invasion of a new habitat and conditions necessary for "invasion" of a new aquacultural method (Table I). With species invasion there are three necessary conditions. First, the species must be physiologically able to cope with the available niches. Secondly, the niches should be unoccupied by other species. Finally, the potential invading species must have physical access to the niches.

[1] C.B.L. Contrib. No. 442

Table I

A parallel is drawn between conditions necessary for species invasion to new habitat and conditions necessary for advancement of molluscan culture method in a geographical area.

Factors necessary for colonization	
Species invasion	Aquacultural method (species)
Available niches unoccupied	Available area not utilized by more primitive technique
Species physiologically able to cope with available niches	New techniques economically viable in the system
Species has physical access to niches	Enterprise must know of available advanced techniques

Similarly, with invasion or advancement of molluscan culture methods there appear to be three prerequisite conditions (Table I). First, the new methods should be economically viable in the area. Second, the area should not be utilized by another, perhaps more primitive culture method. New developments are quite often seen as a threat to security. This leads to resistance to any change. Finally the people who undertake the new methods in an area must know of the advanced techniques in order to try them.

Thus, the state of development of molluscan culture can be viewed in terms of these rather fundamental factors. There are many examples of wild harvest (i.e., surf clams of the Atlantic coast) simply because a more advanced technology is not economically workable. In most areas molluscan culture has advanced to partial husbandry; none, to my knowledge, to complete husbandry. For convenience, I shall describe three examples of the partial husbandry of oysters. These are Japanese raft culture of *Crassostrea gigas,* and the culture of the American oyster, *C. virginica,* on Long Island Sound and in Maryland Chesapeake Bay. Each is in a different state of development and, considering basic factors, each has a different potential to advance.

Japan has the finest examples of the partial husbandry of oysters, with production of about 35,000 tons of shucked oyster meats annually—this is about 1.5 times that of the entire U. S. annual production (Ryther and Bardach, 1968). To give an idea of the intensity of production, in Hiroshima Bay an annual production of 20 tons of meats per acre by rafting techniques has been reported (Anon., 1968). At that rate, the entire Maryland oyster crop of 1967–68 (500 sq. miles of charted oyster bottom) could be matched in less than one square mile (Anon., 1969). The Japanese production has been enhanced through use of rafting techniques which have become very prominent since World War II, bamboo rafts in protected bays and the newer long line technique in exposed waters. It appears that the principal chance for advance might come with the development of genetic stocks by hatchery production, or by hatchery production and commercial use of other species.

Research efforts are beginning in this direction, an example being the Oyster Research Institute at Kesennuma, Japan, established by Dr. Takeo Imai in 1961. By a system of outdoor tanks, they have been able to rear in the hatchery the European flat oyster (*Ostrea edulis*), Portuguese oyster (*Crassostrea angulata*), American oyster (*C. virginica*), Olympia oyster (*O. lurida*), Japanese deep sea scallop (*Patinopecten yessoensis*), northern Japanese abalone (*Haliotis discus*), California red abalone (*H. rufescens*), and the arkshell (*Anadara broughtoni*). All present techniques are prohibitively expensive for commercial application; however, any new technology is initially expensive.

Long Island Sound, in Connecticut and New York, is an oyster producing area which presently satisfies all of the conditions which seem necessary for advancement of culture technique. Before the 1950's, there was a thriving industry based on a system of public and private seed beds, mainly on the Connecticut shore, coupled with growing areas mostly on the Long Island shore. There was then a precipitous decline from a yearly average of about 1,300,000 bushels in 1950–52 to about 40,000 bushels in 1967 (MacKenzie, 1970). The decline was caused by a drastic reduction in natural seed production attributed to several factors including a disastrous storm in 1950 which disrupted existing seed beds, low availability of cultch shells due to loss to the half-shell trade, and increased starfish predation after 1957 (MacKenzie, 1970). Thus, the potential shellfish growing areas are presently not being fully utilized. Presently, Long Island-grown, half-shell trade oysters are fetching about $18 per bushel on the market (much higher than the $5 per bushel for Chesapeake stocks). Thus, any successful technique to produce Long Island oysters should be highly profitable.

With this circumstance, there have been several noteworthy developments. The introduction of large scale investment capital has resulted in the consolidation of many smaller companies into larger units. This has meant that organized research and development capital can be focused on technique advance. There has been greatly renewed interest in the hatchery method of culturing oysters originally begun at the Bluepoints Company, Great South Bay, by Wells and Glancy (see State of N. Y. Cons. Dept., 1969).

In 1968, there were four operational hatcheries on Long Island and one in Connecticut attempting to produce seed economically by the new cultchless setting methods. This, coupled with basic genetic investigation and possible development of superior strains of oysters at the U. S. Bureau of Commercial Fisheries Laboratory at Milford, Connecticut (Longwell, 1970), has created a real basis for potential advance to the full husbandry of shellfish. Advancement of on-bottom culture technique is another noteworthy development in the Long Island Sound area (MacKenzie, 1970). By the use of SCUBA diver observation, the methods and timing of bed maintenance are vastly improved. MacKenzie predicts that the old 1-for-1 yield (bushels of harvest for bushels of cultched spat) can be improved up to 20-1 by these techniques. The Long Island area appears to have excellent potential for advance to complete husbandry.

The Maryland Chesapeake Bay area, although it has undergone great decline in oyster production from historic highs (from a yearly harvest of 16 million bushels in the early 1900's to about 3 million bushels presently), has a different and lower potential for advancement. Early in the century, in

contrast to other areas, Maryland retained the public ownership and management of its oyster bars, which included about 400,000 acres (95%). The resource is managed by the Maryland Fish and Wildlife Administration and fished by some 4,000 licensed watermen. While significant and productive efforts in public management have helped to double production in recent years, the inherent constraints hold down the potential. The Maryland oyster fishery has been cited by Glude (1966) as an unsuccessful fishery under several economic criteria. Moreover, Glude states that Maryland oyster production could be increased from the present 3 up to 40 million bushels per year with the implementation of the best available technology. The reason, perhaps, for the low production figure is that the management agency and the watermen in effect are occupying the "oyster producing niches" in the Chesapeake Bay. The public agency must listen to the wishes of the watermen, who are by nature conservative. New innovations of the department that may materially depart from traditional ways are looked upon as threats to livelihood, and political pressure is applied to keep the status quo. The result of this interaction has, to my mind, resulted in a very low political potential in Maryland Chesapeake Bay for advances in the culture method. The biological potential remains high.

To conclude, it is obvious that most of the world molluscan fisheries are presently operating at a relatively primitive state, vastly under their productive potential. It is also obvious that the advance of shellfish culture to full husbandry would greatly enhance the world's available protein supply.

However, there are many cultural and aesthetic values present in many of our primitive fisheries that may be lost with advancement. The Maryland watermen, for example, are a very close-knit, independent and able breed that is all too rare in America today. The restriction in the Maryland Chesapeake Bay to sail dredging has allowed preservation of the last working sail fleet in the United States. These are very real values that might be destroyed with modernization, in a land where mass production has not brought universal good. In summary, the world molluscan fishery could operate on a more sophisticated and productive basis. We should first learn of the positive and negative values that might result from this before giving our unqualified blessing.

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SURF CLAMS AND OCEAN QUAHOGS

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Surf clams, *Spisula solidissima,* and ocean quahogs, *Arctica islandica,* have been intensively sampled in the middle Atlantic continental shelf to delineate their distribution and density. A hydraulic surf clam dredge sampled an average of 53.8 square meters of bottom at each station during a 5-minute tow; the stations, located 5-nautical miles apart, formed a grid within each of four geographic sample areas used in discussing the results. A scale, rating the importance of each area based on clam abundance, was derived from an analysis of the numbers of bushels taken per station, the numbers of clams caught per station and their shell lengths, and estimates of the standing crop in 1965 (Table I). The average and range of water depths where the clams were found is also given.

The relative importance of geographic sample areas has recently changed because increased fishing activity in the New Jersey area has removed almost 200 million pounds of meats since 1965—this area now would be rated second to the Delmarva Peninsula area. Some of the fleet has moved to beds in the Delmarva Peninsula area and this effort has maintained a high level of production. In 1969, total landings reached a record high of 49.6 million pounds of surf clam meats.

Ocean quahogs, an underutilized resource, are very abundant in the Long Island and New Jersey areas. Dense beds are at depths of water well within the operating limits of the hydraulic surf clam dredge. A small fishery in Rhode Island landed 472 thousand pounds of meats in 1969, which is a significant increase over annual landings of less than 100 thousand pounds during the past decade.

During the 1965 survey, most surf clams were taken from near-shore water to depths of 43 meters; most ocean quahogs were farther offshore at depths of 25 to 61 meters (Fig. 1). Surf clams were taken most often at an average depth of 28.5 meters and ocean quahogs at 41.7 meters. Mixing of both species was most pronounced between 24.5 and 42.7 meter depths. Both species occurred in deeper water and farther offshore at the southern end of their range than at the northern end (Table I). Greater bathymetric records have been reported for both species. The numbers of surf clams taken, however, were low and the shell lengths small. Only the ocean quahog may have significant populations beyond the limits of the 1965 survey.

Materials extraneous to the catch of clams in the dredge indicated that mollusk shells are a significant part of the bottom substrate. Invertebrates often taken in the samples, such as the moon-shell snail (*Lunatia heros*), rock crabs (*Cancer irroratus* and *C. borealis*) and asteroid starfish (*Asterias* sp. and *Astropecten* sp.) were recognized as predators of the clams. Small-sized invertebrates, such as *Astarte* sp. and *Prunum apicinum,* suggested that the

Table I

Survey results for *Spisula solidissima* and *Arctica islandica*—1965.

Geographic Sample Areas	*Spisula soldissima* Abundance Rating	Depth in Meters Average	Depth in Meters Range	*Arctica islandica* Abundance Rating	Depth in Meters Average	Depth in Meters Range
Long Island	3	21	6.2–48.9	1	39	18.4–61.0
New Jersey	1	29	12.3–61.0	2	40	18.4–61.0
Delmarva Peninsula	2	30	12.3–67.2	3	45	24.5–73.4
Virginia-N. Carolina	4	32	12.3–61.0	4	52	36.7–67.2
Grand Average	–	28.5	6.2–67.2	–	41.7	18.4–73.4

dredge would take small surf clams and ocean quahogs. However, no surf clams 30 millimeters or less in shell length were caught and most were more than 100 to 166 mm. long; no ocean quahogs less than 30 mm. long were taken and most were more than 75 to 105 mm. long.

From studies of surf clam biology, it is known that populations off New Jersey can spawn twice in a year. A major spawning occurred in mid-summer followed by a minor spawning in late fall during three of the four years samples were taken. Only a single, late summer spawning occurred during the fourth year. Bottom water temperatures greatly influenced gonadal development. A single hermaphroditic surf clam was found in a sample of 2,500 examined. Larval development through metamorphosis was completed in 19 days at 22°C in the laboratory. A haploid chromosome number of 18 was

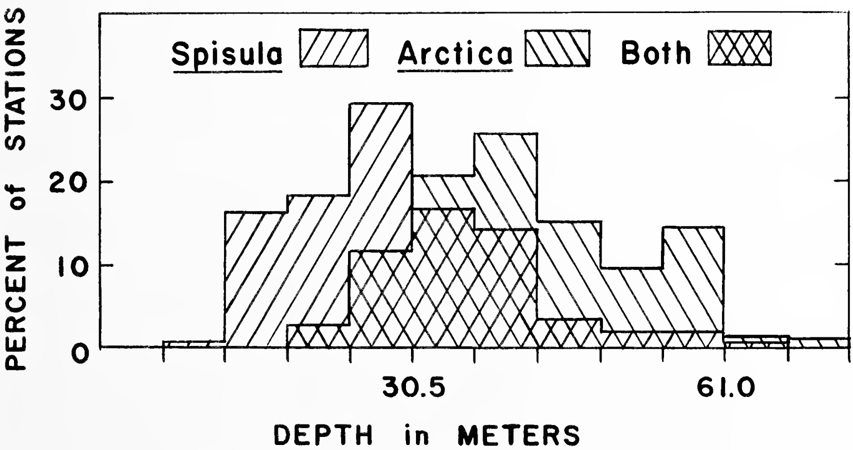

Figure 1. The distribution of *Spisula solidissima* and *Arctica islandica* by depth in the Middle Altantic Bight—1965. (30.5 m. = 100 ft.)

determined from stained squashes of surf clam eggs. Through marking experiments, an adhesive was found to attach streamer tags to the shells and notching techniques were developed to observe clam growth. From our observations of growth during the early life of a surf clam, those 5 to 6 years old generally exceed 100 mm in shell length and are recruits to the fishery. Surf clams are very active burrowers and can disappear within 2 minutes after penetrating the foot into bottom substrates. Leaping from the bottom and crawling over the bottom are two other locomotor activities. In the surf zone, the clams are ineffective against the greater physical forces of wind and waves. Many are washed ashore to die, others are easy prey for shore birds.

THE SEA SCALLOP

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The scallops, even more than the oysters, appear in the relics and records of mankind's antiquity. The stylized scallop shell motif reappears constantly in classical, medieval and renaissance art and architecture—most notably in Botticelli's painting of the goddess Aphrodite rising from the sea. It is safe to venture that when an inlander thinks of a seashell, he unconsciously visualizes a scallop with the beautifully contoured, ridged valve. The sea scallop (*Placopecten magellanicus*) does not fit this idealized picture because of the rather smooth shell, but it is one of the largest scallops in the world, and unquestionably the most valuable commercially.

In the U.S. the sea scallop harvest ranks third in volume, but second in value among the bivalve mollusks—surpassed in total value only by the oyster and ranking slightly higher in value than the oyster per pound of meats. As an example of its value, in 1968 U.S. scallopers landed a total of 14.1 million pounds of shucked meats worth 15.7 million dollars at dockside. U.S. production reached its height in 1961, when total landings exceeded 27 million pounds of shucked meats.

Sea scallops are found on beds of gravel, sand or pebbles, usually mixed with shell. They have rows of functioning bright blue eyes, which line the edges of the mantle, providing a stimulus for movement and escape from predators. The most unique feature of the scallops is their mobility, which is retained beyond the normal pelagic larval life and throughout adulthood. Swimming is accomplished by jet propulsion, water jets being produced by filling the mantle cavity with water and expelling it through two peripheral openings by vigorous contraction of the valves. However, while individuals are quite mobile, tagging experiments indicate that populations do not migrate to any extent.

Sexes of the sea scallop are separate, although rare hermaphrodites occur. The gonads ripen during the summer and spawning occurs from late summer

to early fall. Fertilization and larval development are similar to other bivalve mollusks. Metamorphosing larvae sink and attach themselves to various solid substrates by byssal threads, appearing to favor bryozoans and other branching forms of life for anchorage. The byssal attachment can be released at will and the young scallop can move on so seek more favorable sites. Growth is fairly rapid, and by the second year the shells average over 1½ inches in diameter. Commercial size is reached in 4 years at almost 4 inches in length. Occasionally very large sea scallops have been reported with an estimated age of 18–20 years and a diameter of about 9 inches.

Although the normal exigencies of larval and juvenile life take their toll, predation, parasitism and disease do not appear to impair the recruitment of the species—except for the predation by man. Boring sponges and worms damage the shells and probably weaken the mollusks; bottom-feeding fishes consume young scallops; but no lethal epizootic organisms are known. Where mass mortalities do occur they are most likely attributable to deleterious environmental changes—particularly increased water temperatures.

The sea scallop, as its name implies, is an inhabitant of relatively open oceanic waters. It ranges from the Gulf of St. Lawrence to Cape Hatteras. Aside from the major offshore concentration on Georges Bank, scattered but substantial coastal populations are found in the Gulf of Maine and off the mid-Atlantic coast from Cape Cod south to the Virginia Capes. Sea scallops are intolerant of temperatures above 68° F and their entry into salt bays and estuaries, as well as the southern limits of the range, are doubtless circumscribed by temperature. In Maine and Canada, they are present in cold and saline inland waters, like Passamaquoddy Bay. In the northern portion of the range, scallops may occur in relatively shallow beds, while southern concentrations exist in deeper beds, where the water remains cool.

The sea scallop fleet consists of comparatively large vessels, about 85 to 100 feet long, diesel-powered and seaworthy. Fishing is carried on 24 hours a day during 8 to 10 day cruises. The 10 to 20 man crews are divided into 2 six-hour watches for the duration of the trip. The scallop dredge consists of a heavy metal frame mounted on runners and a bag knit of steel rings with a 3 inch inside diameter. Dredge tows are usually 20 to 30 minutes long, depending on the abundance of scallops. Two dredges are towed simultaneously. The dredges are hauled up and the contents dumped on deck and culled. Scallops are shucked on deck, the meats washed in seawater, packed into clean muslin bags holding about 40 pounds, and stored under ice. The bulk of the yield is stored frozen until sold to restaurants and retail markets in raw form. An increasing percentage is processed into precooked convenience foods, such as TV dinners, which are, in turn, frozen for retail sale.

Distribution surveys have effectively delineated the areas of commercial abundance. Since the fishery is to a large extent in international waters, resource management is both physically and politically difficult. Control, such as does exist, is exercised by the International Commission for the Northwest Atlantic Fisheries.

From almost nonexistence before World War II, the sea scallop fishery has expanded to become one of the most economically important offshore fisheries of the New England area. Remarkable increases in landings resulted

Table I
Trends in the Atlantic Coast Sea Scallop Fishery, as Shown by Fishing Effort and Average Annual Landings

	Fishing Effort*		
Years	U.S.	Canada	Average Annual Landings (Millions of Pounds)
51–53	12.6	0.8	21.5
54–56	12.9	1.3	21.9
57–59	11.8	2.0	25.3
60–62	10.1	3.7	36.7
63–65	8.8	8.1	35.4
66–68	7.8	9.5	28.0

* Equals thousands of days per year fished

when larger fishing vessels began fishing further offshore and remaining on the grounds for several days at a time before returning to port. Most of the production, averaging about 85% of the total over the years, comes from the relatively restricted offshore area of Georges Bank. Minor landings, usually about 10% of total production, occur at several ports along the middle Atlantic coast. Small numbers of sea scallops are taken along the coast of Maine, at Cape Cod, and at other inshore coastal areas.

Sea scallop production reached its height during the early 1960's (Table I). During this time, Canada built or diverted many vessels to the main scallop fishing grounds until now she controls a fair share of the fishery. Successful populations of sea scallops on Georges Bank have maintained the fishery for years at a high level of production. U.S. production there reached its height in 1961 when 23.6 million pounds of shucked meats were landed. Since then U.S. landings have declined as Canadian competition has increased. This is easily seen through the increase in Canadian effort through the years 1951 to 1968 (Table I). In the early years the U.S. had a commanding lead in fishing effort which has gradually dwindled to about two-thirds of its former strength. During the same period the Canadians have risen from almost no effort to a point where their effort exceeds the U.S. This is reflected in total landings, and Canada now commands better than half the market. Near the height of production the price of landed scallops reached such marginal levels that vigorous marketing campaigns were necessary to make a larger portion of the consumer public conscious of this delectable product.

Most of the U.S. fleet is based at New Bedford, where the catches are sold at auction. Nearly all of the Canadian catch is exported to the U.S. In evaluating the actual size of the catch it should be borne in mind that only the large adductor muscle, perhaps one-third of the shell contents, is utilized for food, while the rest is discarded. The harvests quoted above include only the shucked adductor muscles.

In 1965 sea scallops on Georges Bank were somewhat less abundant than usual and fishermen looked elsewhere for concentrations of sufficient densities

to merit exploitation. Populations were found off the middle Atlantic coast in aggregations strong enough to warrant heavy fishing, and in the second half of 1965 the entire U.S. scallop fleet diverted to this area (mostly offshore of Chesapeake Bay, Virginia, and near the Hudson Canyon, off New Jersey). Some of the Canadian fleet also fished the area during this time. The fleets had great success here which resulted in a significant change in the landings picture. For the first time in the years that Georges Bank had been fished, a greater part of production was landed from other areas (6 million pounds from Georges Bank; 13.9 million pounds elsewhere).

The 1965 (and longer) windfall of sea scallops from the middle Atlantic area gave Georges Bank, an area heavily fished for years by both U.S. and Canadian scallop fleets, a much-needed chance for recuperation of scallop densities. Since 1965, the U.S. fleet has continued its main efforts on the mid-Atlantic stocks, while Canada has steadily increased its efforts on the traditional grounds. This diversion of effort between the two countries has helped to maintain relatively high total landings. Georges Bank will remain the main scallop grounds over the years because of the proven ability of these stocks to continuously repopulate themselves. However, when a scarcity of scallops exists on the Banks, the middle Atlantic will continue to produce "reserve stocks," in areas not predeterminable, that can be drawn upon in times of stress. Total sea scallop production has probably already reached its maximum level of sustainability and should remain as it has over the past few years with minor fluctuations.

THE CALICO SCALLOP: FISHERY AND RESEARCH DEVELOPMENTS

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The calico scallop, *Argopecten gibbus,* is found in open marine waters throughout the Gulf of Mexico and in the western North Atlantic from off Delaware Bay to the northern side of the Antilles. This scallop has been taken in depths of 5 to 200 fathoms with a bottom water temperature range of 14° to 33°C. This species is usually found in abundance on sand-shell bottoms near prominent coastal projections.

The largest population of calico scallops thus far discovered is in the Cape Kennedy area off the east coast of Florida in depths of 10 to 40 fathoms. Smaller, less stable populations of commercial importance are found off Cape San Blas in the northeast Gulf of Mexico and in the Cape Lookout area off North Carolina.

The development of efficient shucking and eviscerating machinery has made harvesting this small (50–65 mm in shell height) scallop economically

feasible. Scallops as small as 45 mm in height are acceptable for machine processing. Commercial quantities of calico scallops with a shell height greater than 70 mm are uncommon—maximum size is about 80 mm.

Calico scallop concentrations are considered commercially significant if a 30-minute tow with an 8-foot tumbler dredge will produce 40 or more pounds of scallop meats.

Converted shrimp trawlers, scallop draggers, and specially designed 85-foot factory-type vessels have been used to catch calico scallops. Shellstock on the Cape Kennedy and Cape San Blas beds is generally taken with 8- or 10-foot scallop tumbler dredges, while in the Cape Lookout area, recently designed and highly efficient scallop trawls are preferred.

At present there are two trends in the calico scallop fishery: that of using a factory-type vessel to machine-process the catch at sea, and the use of catcher boats to supply shellstock to shore-based processing houses.

Commercial production has fluctuated widely for a variety of reasons. High seas, hot weather, malfunctioning of processing machinery, and shellstock availability have influenced production rates to some degree in all areas of the fishery.

The Bureau of Commercial Fisheries is monitoring the calico scallop stocks through resource assessment and biological research.

The assessment program is being conducted by the Exploratory Fishing and Gear Research Base, Pascagoula, Miss., by means of transect dredging, observations from submersibles, and more recently, by use of a bottom-viewing device called RUFAS (Remote Underwater Fishery Assessment System). RUFAS is a remote controlled underwater sled containing a TV and underwater motion picture camera. The towed sled is maintained about 5 feet off the bottom and is steered by the towing vessel. As the sled passes over the scallop beds, continuous or intermittent motion pictures or video tapes are taken of scallop concentrations. This information is plotted and made available to the scallop industry. Scallop densities exceeding 8 per square foot have been recorded by RUFAS on the Cape Kennedy beds.

Biological research on the calico scallop is being conducted by the Tropical Atlantic Biological Laboratory, Miami, Florida. Studies on spawning, larval development and dispersal, spat set, age, growth, movement, mortality, and environmental factors affecting the scallop beds are in progress.

Calico scallops have been spawned in the laboratory, and the larvae reared to the veliger stage.

Two offshore study sites have been established on the Cape Kennedy scallop beds as this animal is one almost ideally suited for study by direct observation. At these locations, SCUBA divers have installed spat collecting devices, current and temperature recorders, and they have placed marked[1] scallops on the bottom for age, growth and movement studies.

It is anticipated that the underwater study sites will answer many basic questions about this new and valuable resource.

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[1] The shell marking agent used is All-Crete, a quick-setting cement that hardens underwater. A paper entitled "Marking Mollusks with Quick-Setting Cement" is in manuscript and will be published in the near future.

HISTORY AND CURRENT STATUS OF THE SUNRAY VENUS CLAM FISHERY IN NORTHWEST FLORIDA

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A new fishery was initiated in February 1967 near Port St. Joe, Florida, for the sunray venus clam, *Macrocallista nimbosa* (Solander). This marked the first commercial harvest of this species and was accomplished under a permit issued by the Florida Department of Natural Resources (then the Florida Board of Conservation) which required that a Department biologist accompany the clam vessel during the first few months of harvesting. Thus was realized a very rare opportunity: to observe the initial utilization of a virgin resource.

Mr. George Kirvin, owner of Quality Seafoods of Apalachicola, Florida, discovered this rich bed of sunrays and modified his 65-foot shrimp trawler to harvest his discovery. Originally Mr. Kirvin equipped his vessel with a 27-inch "Nantucket" dredge, which uses water pressure (provided by a 1,000 gallon-per-minute pump driven by a large deck engine) to dig the clams and force them back in to the metal catch container. The entire unit (dredge, water hose, and clams) is then lifted onto the deck with an "A" frame, emptied, and returned overboard to continue fishing. A tow time of 10 to 15 minutes was preferable, preventing overfilling of the dredge and undue breakage of clams.

The biologist participated in 50 harvestings trips (days) during February, March, April, May, and June 1967. The average number of bushels per 10-minute tow during each month ranged from 2.5 to 8.7 and the average catch per day for each month ranged from 109 to 331 bushels. The largest single day's catch was over 570 bushels and the total catch was approximately 10,300 bushels.

Clams on the grounds were quite uniform in size, averaging about 130 mm in length, and preliminary growth studies indicated that these animals may be as much as four or five years old. These data also implied that growth was much more rapid in the smaller clams and that a length of almost three inches might be possible in their first year.

In contrast to the rather uniform length found on the fishing grounds, catch lengths with the same gear in inshore (shallow) waters ranged from 25 to 130 mm. The dominance of smaller clams inshore and the completely opposite situation offshore suggest a movement of young adults from the inshore areas to the offshore fishing grounds.

This fishery is continuing and although many advances have been made since those first months of harvest, problems still exist. The most significant is the apparent small size of the fishing grounds. There are now two vessels with 60-inch dredges which fish the grounds, catching from 150 to 400 bushels each per day. A bushel of clams brings $1 to the boat, an amount which is divided among the three crew members (15¢ each) and the vessel (55¢). At the fish house, one bushel yields 9 to 11 pounds of cleaned, shucked meats which sell for 28¢ per pound.

Even though there is not yet any concrete evidence of a decline in the fishery, the fishermen themselves are concerned and would like to find new beds with the same high concentrations of clams. Because of this need our Marine Research Laboratory outfitted its research vessel, the *Hernan Cortez* (a 72-foot St. Augustine shrimp trawler), with an "A" frame and Nantucket dredge.

Exploratory sampling in depths from 15 to 70 feet has been accomplished from Apalachicola to Pensacola and is now continuing in the Cedar Key area. Thus far extremely heavy populations, such as those in the Port St. Joe area, have not been encountered, but the samples are by necessity rather widespread and the area is extensive. Catches near Fort Walton Beach and Cedar Key were relatively good, however, and following completion of the broader sampling, work will be concentrated in areas showing the most promise.

In addition to the strictly exploratory efforts, valuable data are also being obtained on the occurrence, distribution, abundance, and bathymetric range of the sunray venus. Work has already indicated that these clams are restricted almost entirely to depths of 35 feet or less and that the greatest concentrations occur in quartz sand. Records are being maintained on the species diversity and abundance of all other fauna taken in the Nantucket dredge. Size is recorded for selected species which have commercial possibilities and many specimens are retained for the invertebrate reference collection.

Marking studies have been continued to obtain more data on growth rates and to determine if there is a movement of animals from inshore to offshore.

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CEPHALOPOD RESOURCES AND FISHERIES IN THE NORTHWEST ATLANTIC

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Recent harvesting of major groundfish species at or beyond maximum sustainable yields emphasizes the need to diversify fishing efforts in the Northwest Atlantic. Cephalopods comprise an underexploited resource here as in many other areas, the region herein considered being that from Cape Hatteras to West Greenland (the ICNAF convention area). For data on the Caribbean and northeast Pacific the reader is referred to Voss (1959) and Fields (1965) respectively.

While there are many species of cephalopods in the oceanic zone (see Mercer, 1968) only a few are accessible to standard fishing gears inshore and

on the continental shelf. The oegopsid *Illex illecebrosus* and myopsid *Loligo pealei*, squids presently exploited commercially, offer far more potential for an expanded fishery than do other forms; only these species will be considered although the possibilities of future oceanic fisheries are not to be dismissed (see Clarke, 1963).

Illex illecebrosus. This ommastrephid is a seasonal migrant to Newfoundland waters where it is fished from about mid-July to late October or early November each year. It occurs inshore sporadically southward to Cape Cod but south of there it is generally restricted to the continental shelf and slope. For data on its biology see Squires (1957) and Mercer (1965).

The Newfoundland fishery is passive in that it is based entirely on availability of squid to jigging devices in inshore waters of less than about 20 meter depth. Fluctuations in catch thus reflect variations in local distribution in relation to environmental parameters and variation in behavior with regard to jigs; also the northern extent of the summer distribution varies yearly. It is clear that Newfoundland landings could not be taken as an accurate index of population sizes even if fishing effort were constant.

Since the species is presumably monotelic and probably lives only one or two years (see Squires, 1967), wide fluctuations in stock sizes are to be expected. The short life span and single year class entering the fishery preclude anything but short term prediction of stock size for any given year class, even with hitherto unavailable data on abundance and mortality of young juveniles. No cycle or correlations of abundance with environmental parameters have been demonstrated. However a rough correlation between catch rate of the northward migrant squid on the southwest slope of the Grand Bank in May and June and subsequent inshore landings allows for a crude forecast shortly before the fishery commences (Squires, 1959).

Recent annual landings at Newfoundland have ranged from nil to 10,500 metric tons, most of which is exported to Norway and Portugal for use as cod bait. In years of abundance, the resource inshore is enormous. At an average weight of 830 kg. (Sergeant, 1962) and a feeding rate of 4–6% body wt/day (extrapolated from congeners, data from Sergeant, 1969) the 10,000 pilot whales (*Globicephala melaena*) taken on the east coast of Newfoundland in 1956 alone would eat approximately 33,000 to 55,000 metric tons of squid in a 100-day season. (This odontocete feeds almost exclusively on *Illex* in Newfoundland inshore waters--Sergeant, 1962.) This is 4–5 times as great as the largest squid catch in one season for all of Newfoundland, indicating that fishing mortality is a small percentage of total mortality for squid in this area.

Loligo pealei. This neritic loliginid is most abundant from Cape Cod to Cape Hatteras. In winter the population is most concentrated just below the shelf break of the mid-Atlantic Bight (Summers, 1969; Vovk, 1969; Mercer, 1969b) where it is accessible to the trawl fishery; the larger squid generally migrate deeper. Diurnal variation in availability to otter trawls indicates vertical dispersal at night (Summers, 1969). Summers estimated late winter abundances in the Bight at 3.4 and 2.1×10^6 kg. respectively for 1967 and 1968

but, as he noted, these figures are extreme underestimates and are of minimal population sizes since the sampling time was just prior to the breeding season.

Vovk (1969) analyzed 3,420 trawl sets made from Georges Bank to Cape Hatteras by vessels of the Soviet *Atlantniro* in 1958–1968. He reported largest catches in June-November northeast of Blake Canyon. Catch per hour averaged 0.5–1 metric ton and ranged to 6 tons on the southern slopes of Georges Bank. Catches of 25 tons were made in 60–100 meters off Wilmington, Delaware and Baltimore, Maryland, abundance in a 30 square mile area off Wilmington being estimated at 6–7,000 tons.

In December 1969, Japan commenced trawling for squid off New York with 14 vessels; the number of vessels dropped to 6 in April because of decreasing catches. Landings to April were estimated at 13,000 metric tons, these being sold in Europe (Anon., 1970). Spain, the largest buyer, is reportedly planning to fish squid in the same area during the 1970–71 season.

In summer, squid from the Bight migrate up to 600 miles north and 200 miles inshore (Summers, 1969) where breeding occurs, and here they are taken by various inshore gears from about mid-May to mid-November. Recent annual landings have averaged about 1,500 metric tons (see Lyles, 1968).

Discussion and conclusions. Northwest Atlantic cephalopods are presently being exploited at levels far below maximum sustainable yields. However it is likely that the fishery will expand rapidly in the next few years and long term investigations on population structure and dynamics are required to assess the effects of more intensive fishing on the stocks. While some progress has been made in characterizing *Illex* stocks by size distributions, maturities and parasites (Mercer, 1969a, and in prep.), in the author's opinion, population genetic studies utilizing protein polymorphisms offer greatest promise in this regard.

Since fecundities are high, natural mortalities must be correspondingly high and, from experience with teleosts, one would intuitively hypothesize that the difference between good and bad year classes is established by density-dependent and environmentally related mortality in early stages. Gulland (1965) argued convincingly (for teleosts) that understanding of happenings in early stages will accrue from normal population dynamic techniques rather than from correlation studies with environmental parameters. This indicates another important direction for research on *Loligo*; the early life history of *Illex* is hitherto undescribed.

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CONCH FISHERIES

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The term "conch fishery" usually is taken to apply to the commercial catch of the knobbed and channeled whelks, *Busycon carica* and *B. canaliculatum,* along the eastern seaboard of the continental United States, although the term "conch" is frequently used in reference to any of the large prosobranch gastropods, particularly in the families Strombidae, Cassidae, and Galeodidae. The recorded landings of all gastropod mollusks utilized for commercial purposes in America are herein considered as conch fisheries. In addition to *Busycon,* the fisheries for *Littorina* and *Thais* along the coast of Maine, and for *Haliotis,* the abalone, are the only significant enterprises to bear attention.

Fishery Statistics of the United States, an annual report published by the Bureau of Commercial Fisheries of the Department of the Interior, is the principal source of data on the commercial catch of conchs in the continental United States. In the West Indies, including Puerto Rico and the Virgin Islands, *Strombus gigas* is marketed for human consumption (Doran, 1958). Since the stromb-fishery in the Bahamas at one time was worth nearly a quarter of a million dollars a year, it has been suggested that this species is particularly suitable for farming (Randall 1964; Iversen 1968). Finally a brisk trade in shells as collectors' objects is maintained in this country and,

though few data are available, it has been estimated by the Commerce Department that over $15,000 worth of shell-trinkets and related objects are imported into Florida from the Bahamas each year (Boss, 1969).

The shell fishery for conchs in the United States consists of a minor commercial venture in comparison to the fisheries for scallops, soft-shelled clams, and quahogs. Presently only three processing plants (New York, New Jersey, and Delaware) handle the commercial catch along the eastern coast; elsewhere conchs, limpets, periwinkles and the like are sold directly in markets or are served in specialty restaurants, particularly Chinese and Italian.

The conch-fishery for *Busycon* in the New England (Massachusetts, Rhode Island, and Connecticut), the Middle Atlantic (New York and New Jersey) and the Chesapeake (Maryland and Virginia) regions varies greatly from year to year. During the last ten years, 1966 was a peak period with over a million pounds of conchs harvested along the eastern Seaboard. The year 1963 was good in the Middle Atlantic Region with over a half million pound catch, and 1962 in the Chesapeake Region with more than 400,000 pounds. In 1966 in the South Atlantic Region (North and South Carolina, Georgia and eastern Florida) the best prices were fetched, about 38 cents/lb., though the catch was only 310,000 pounds. The price per pound varies from state to state and usually the best prices are paid in the Middle Atlantic Region (between 22 and 25 cents/lb.). In general, there has been an upward trend in the *Busycon* fishery. Prices per pound as well as the annual catch have increased slightly during the last ten years.

In Maine, a small fishery for *Littorina* and other rock dwelling gastropods, *Thais* and *Acmaea,* exists and the annual harvest averages 50,000 pounds with a commercial value near $12,000.

Probably the most important gastropod fishery in the United States is in California where several species of *Haliotis* are taken commercially for a total annual value of nearly $1.5 million after processing. Recently this fishery has been threatened by overfishing and the return of the sea otter; some areas, which supported an active industry with many divers and vessels, have recorded a marked reduction in the fishery during the last ten years (Turner, 1970).

Since the conch-fishery in America is relatively small, the potential for an expanded industry is considerable. Several foreign nations, notably India and Japan, have substantially larger fisheries for marine gastropods. As world food resources dwindle in the face of greater demand, and as the tastes of gourmets grow to include these delicacies, the conch-fishery might be considered as an expandable industry in mariculture.

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PREDATORS AND DISEASES OF COMMERCIAL MARINE MOLLUSCA OF THE UNITED STATES

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Among the many environmental factors preventing the full expression of the biotic potential of commercial marine mollusks are predation and disease. These two factors are partially density dependent, and may at times be dominant influences on population size of commercial species.

The more important predators of marine Mollusca are starfish, flatworms, predacious and parasitic snails, crabs, fishes, and cephalopods. The importance of a number of these predators—particularly starfish, crabs, and fishes—has been well established, but there have been recent developments of interest with certain other predators. Although known for at least 60 years as oyster pests, it is only recently that the very serious predation of polyclad flatworms on oysters has really begun to be appreciated. Entire sets, especially of cultured oysters, may be completely destroyed by these flatworms. Problems with drills have recently been intensified by continuing promiscuous transfers and introductions of commercial mollusks, since existing inspection systems are inadequate to prevent simultaneous introduction of predators, parasites, and pathogens.

A number of animals best described as epibionts or competitors can have severe effects on growth and survival of commercial species. Mud blister worms—small annelids—are damaging pests of oysters, while barnacles, tube worms, and corals can reduce survival of calico scallops. With these animals as well as with predators and parasites, population explosions—periodic and possibly even cyclic—place severe stresses on populations of commercial Mollusca, undoubtedly producing some of the population crashes that have occurred in the commercial species.

Diseases of mollusks, especially of oysters, have received recent attention because of destructive epizootics and resulting mass mortalities. Four diseases have been demonstrated to cause mortalities in American oysters—Malpeque Disease, Delaware Bay Disease, Seaside Disease, and Dermocystidium Disease. Major economic losses have resulted from outbreaks, and control measures are still relatively ineffective. Recent developments in other disease areas include increasing reports of neoplasms in bivalves, and studies of nematode parasites of scallops and abalones.

Few of the diseases of mollusks are transmissible to humans, but there are a number of human diseases that result from passive transfer or accumulation of chemicals or pathogenic microorganisms by mollusks used as food (especially if eaten raw). Included here would be hepatitis, typhoid fever, paralytic shellfish poisoning, insecticide poisoning, and heavy metal poisoning.

The dominant role played by predation and disease in molluscan populations is slowly being elucidated. A new element, introduced by developing

cultural practices for certain commercial species, concerns the control of these and other environmental factors—reducing or eliminating their impact on molluscan populations.

POLLUTION AND COMMERCIAL MARINE MOLLUSKS

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Pollution is a word very much in the limelight today. Ketchum (1967) defines pollution as "any substance added to the environment . . . which has a measurable and generally detrimental effect upon the environment." This effect can take many forms including excessive nutrients, depressed oxygen levels, increased particulate matter, chemical and biological inhibitors, poisons, excessive heat, radioactive wastes, or, in the marine environment, too much freshwater. Mollusks which are used commercially can be concentrators of pollution; they can become contaminated with human disease organisms and unacceptable flavors. Pollution affects commercial mollusks, therefore, in two ways: by so altering the environment that mollusks cannot survive, and by so contaminating the mollusks that they are not suitable for human consumption. Among the many gradations that occur between extremes of toxicity, it should be noted that pollutants are often especially lethal to larval forms, and adult mollusks may survive conditions that are toxic for their larvae.

Commercial mollusks are particularly susceptible to pollution because they are found in areas where pollution frequently occurs and because they are essentially sedentary animals and cannot leave the polluted area. Since estuaries and continental shelves where mollusks are fished are bordered by human activity, the sources of pollution are close to hand and the pollutants are more concentrated than in open waters of the ocean. Sources of pollution range from freshwater to pesticides, and include domestic sewage, liquid waste products from agriculture and animal husbandry, heavy metals, petrochemical wastes, pulp mill wastes, radioactive wastes, detergents, and excessive heating of water. Freshwater runoffs differ from the other sources in that they are rarely attributed to human activity; but the sudden and extreme change in the chemical nature of the environment that they cause has been responsible for serious mortalities in oysters (Engle, 1946). The silting accompanying a freshwater runoff can clog the gills of oysters so that they smother, or may bury them completely (Waugh, 1953). Domestic sewage not only is a main source of contamination but also adds nutrient materials which cause oxygen depletion and encourage the development of microorganisms toxic to mollusks. Similar adverse effects come from agricultural practices—the instance of pollution by manure from the duck farms in Moriches Bay, Long Island is well-documented (Redfield, 1952) and farm fertilizers washed down by heavy rains have been suspected of contribution to the over-enrichment of estuarine waters.

Another industrial by-product, liquor from pulp mill operations, causes physiological damage to the filtering and feeding mechanisms of oysters (Hopkins, Galtsoff, and McMillin, 1931). Radioactive wastes are not, at present, much of a problem, principally because disposal has been so carefully monitored. It should not be forgotten, however, that the ability of commercial mollusks to accumulate trace elements would make them particularly likely to take in these radioactive wastes and so become contaminated.

Mollusks have the ability to concentrate trace substances many times greater than the levels present in their environment, and both heavy metals and pesticides are accumulated in this manner. This accumulation can upset the physiological processes of the mollusks—heavy metals may act as inhibitors to enzyme action and pesticides have been shown to inhibit shell movements of oysters and so curtail growth (Butler, 1966)— and it also makes them unsuitable as food. Shellfish can purge themselves of these substances if the source of pollution is removed and generally can recover if the damage has not been too great. Shellfish have been found to vary in their response to heavy metals. For example, copper has been found to be most toxic to the soft-shell clam and the edible mussel, zinc and cadmium accumulate most rapidly in the soft-shell clam, and the oyster is most likely to pick up lead. A mussel in Japanese waters was one of the principal carriers of mercury which, when ingested by humans caused the notorious "Minamata" disease.

The continued presence of petroleum oils in shellfish waters creates adverse conditions because the toxic substances released from oil interfere with the feeding mechanism of oysters and affect the growth of some of their natural food (Galtsoff, Prytherch, Smith, and Koehring, 1935). The detergents which have been used to clean up oil spillages have a much more drastic and immediate effect, however, and limpets that had been observed grazing on rocks covered with weathered oil were killed by the detergents used to remove the oil (Smith, 1968). Detergents were also toxic to topshells, winkles, mussels, and many larval mollusks. Shellfish harvested from oil-contaminated waters have a bad taste and are not acceptable for human consumption.

Thermal pollution is, perhaps, the one type of pollution which, if properly controlled, particularly during the cooler seasons, might be turned to advantage for commercial mollusks through the development of aquaculture. Nevertheless, any sudden and extreme heating could be dangerous for larvae and make the environment generally unsuitable through oxygen depletion.

The effect of pollution in molluscan populations has been most thoroughly studied in oysters, but, within the limits set by species differences, it would seem that all commercial mollusks have been affected by the pollutants mentioned. Nevertheless, instances have been rare when the pollution was so severe that an entire population was dangerously affected. More common are the situations where commercial mollusks have been implicated as carriers of human disease, resulting in adverse publicity for the entire shellfish industry.

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SYMPOSIUM ON COMMERCIAL MARINE MOLLUSKS SUMMARY

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United States commercial marine fisheries operate in waters of brackish to oceanic salinities. The fisheries can be separated in to two categories, those for coastal and inshore species and those for oceanic species. Coastal and inshore fisheries brought in 90 million pounds of meats in 1967, compared to 80 million pounds of meats from the oceanic fisheries. One of the inshore fisheries, that for oysters, accounted for 60 million pounds of meats in 1967 and, in addition, was the most valuable of all our mollusk fisheries. The largest oceanic fishery was for surf clams, but hard clams and scallops exceeded the surf clam in value although producing only one-third and one-fourth the volume of the surf clam fishery (see Table 1).

The inshore oyster fishery is harvested in a number of ways, from the traditional and technologically backward hand tonging and sail dredging, characteristic of the Chesapeake Bay area, to the more advanced methods of culture followed on Long Island and on the west coast. Much interest has been shown in modernizing oyster harvest methods, with an eye to increased efficiency in the fishery.

Inshore and coastal fisheries exist for hard and soft clams, *Rangia,* and razor clams. The fishery for the Pacific coast razor clam (*Siliqua*) is at present much larger than that for the east coast razor clam (*Ensis*) but there is a possibility of developing both a commercial and a sport fishery for *Ensis.* Many Pacific coast clam fisheries are now almost exclusively sport fisheries. The major Atlantic inshore clam fisheries, those for hard and soft-shell clams, show considerable variety in the technology employed; from primitive handraking and digging for the hard and soft clams to the mechanized dredges used in harvesting hard clams in Long Island Sound and the soft clams in Chesapeake Bay. The use of the escalator dredge has been a major factor in the remarkable growth of the soft-shell clam industry in recent years.

Table 1

U. S. MOLLUSCAN SHELLFISH CATCH–1967

Arranged by Region* (Thousands of Pounds and Thousands of Dollars)

Species	New England	Middle Atlantic	Chesa-peake	South Atlantic		Pacific	Total Catch	Total Value
Oyster								
Eastern (*Crassostrea virginica*)	323	1,190	25,798	3,160	21,747	13	52,231	$29,106
Pacific (*Crassostrea gigas*)	–	–	–	–	–	7,682	7,682	2,993
Western (*Ostrea lurida*)	–	–	–	–	–	44	44	140
Clam								
Hard (*Mercenaria mercenaria*)	2,899	10,243	2,156	234	354	296	16,182	11,981
Ocean Quahog (*Arctica islandica*)	45	–	–	–	–	–	45	6
Rangia (*Rangia cuneata*)	–	–	–	86	–	–	86	27
Razor (*Siliqua patula, Ensis directus*)	5	16	–	–	–	283	304	180
Soft (*Mya arenaria*)	4,207	373	5,243	–	–	–	9,823	3,936
Surf (*Spisula solidissima*)	16	43,889	1,149	–	–	–	45,054	4,352
Scallop								
Bay (*Argopecten irradians*)	455	248	–	387	7	–	1,097	1,053
Calico (*Argopecten gibbus*)	–	–	–	1,410	–	–	1,410	317
Sea (*Placopecten magellanicus*)	7,025	1,585	1,632	–	–	–	10,243	7,767
Periwinkle (*Littorina* sp.)	54	–	–	–	–	–	54	14
Squid (*Loligo* spp.)	1,819	1,393	584	42	48	19,606	23,492	663
Octopus (*Octopus* spp.)	–	–	–	2	–	49	51	10
Conch (*Busycon* spp.)	170	215	412	12	3	–	812	134
Abalone (*Haliotis* spp.)	–	–	–	–	–	888	888	865
Mussel, Sea (*Mytilus edulis*)	775	28	–	–	–	–	803	101
TOTALS	17,783	59,180	36,974	5,333	22,159	28,861	170,301	$63,645

* Source: Bureau of Commercial Fisheries Office of Statistical Services

An example of a coastal fishery which is at present underexploited, but with great potential, is found in the fishery for the blue or edible mussel. European methods of culture and management of this shellfish could be followed with profit in the New England area. Other New England coastal fisheries, such as those for the bay scallop and the periwinkle, may be amenable to further exploitation.

Fisheries for gastropods, such as the small periwinkle fishery off Maine, are of less importance than those for the bivalves, but the abalone fishery of the west coast is of some significance, and offshore fisheries for conchs are considered an underutilized but growing industry. Most of these fisheries brought in less than a thousand pounds of meats in 1967, but the abalone realized four to five times as much. Among the cephalopods, squid and octopus are fished in both Atlantic and Pacific waters, with greater abundance in the Pacific.

Surf clams and sea scallops are the outstanding shellfish caught in ocean waters off the United States. Both these industries grew rapidly in the 1940's and have flourished impressively since then. The calico scallop fishery is a very recent addition and is still in the exploratory stage as is the fishery for the sunray venus clam. Surf clam and sea scallop biology are quite well understood, but much is yet to be learned about the extent of the resources and the population dynamics of the other species.

Pollution of the coastal environment and molluscan habitat is a long-standing problem that constantly constricts the available area for commercial mollusk production. In recent years, pollution has removed vast areas of commercial shellfish from utilization for human food, largely through more critical assessment of domestic pollution by Government agencies and more stringent requirements for food purity, but also through real increases of industrial pollutants. Closely related to the pollution problem are those of predation and disease causing extensive mortalities in shellfish populations. Some shellfish diseases are critical in the area of public health, but most are restricted to the invertebrate populations. Finally, we must realize that molluscan resources are not inexhaustible and that some populations are near or at the point of being overfished. Good management and assessment techniques are required to prevent overexploitation.

To sum up, the United States enjoys a large and varied fishery for commercial mollusks, both inshore and offshore. In a few cases, the fisheries are well managed; in others, they are underutilized because of primitive methods of fishing, because of lack of information about the extent of the shellfish resource, or because the market value has not yet been developed. Disease and predation have always been factors that have limited the size of the shellfish resources. Now, however, a third factor has come in—pollution—and this may turn out to be the most serious problem that the shellfisheries have to face. There is no doubt that many of these problems can be resolved, and the commercial mollusks of the United States will continue to play an important role in our fisheries economy.